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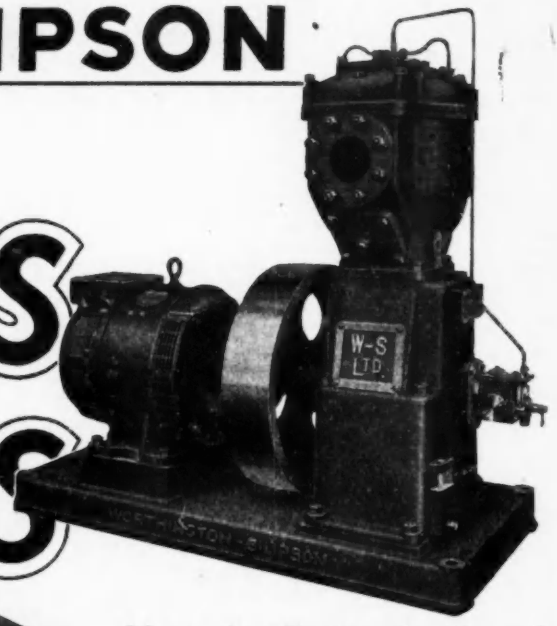

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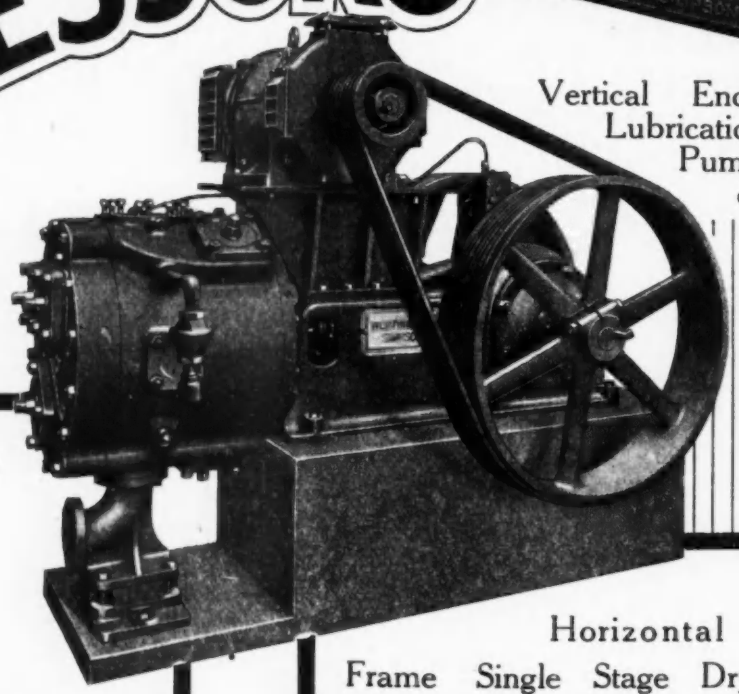

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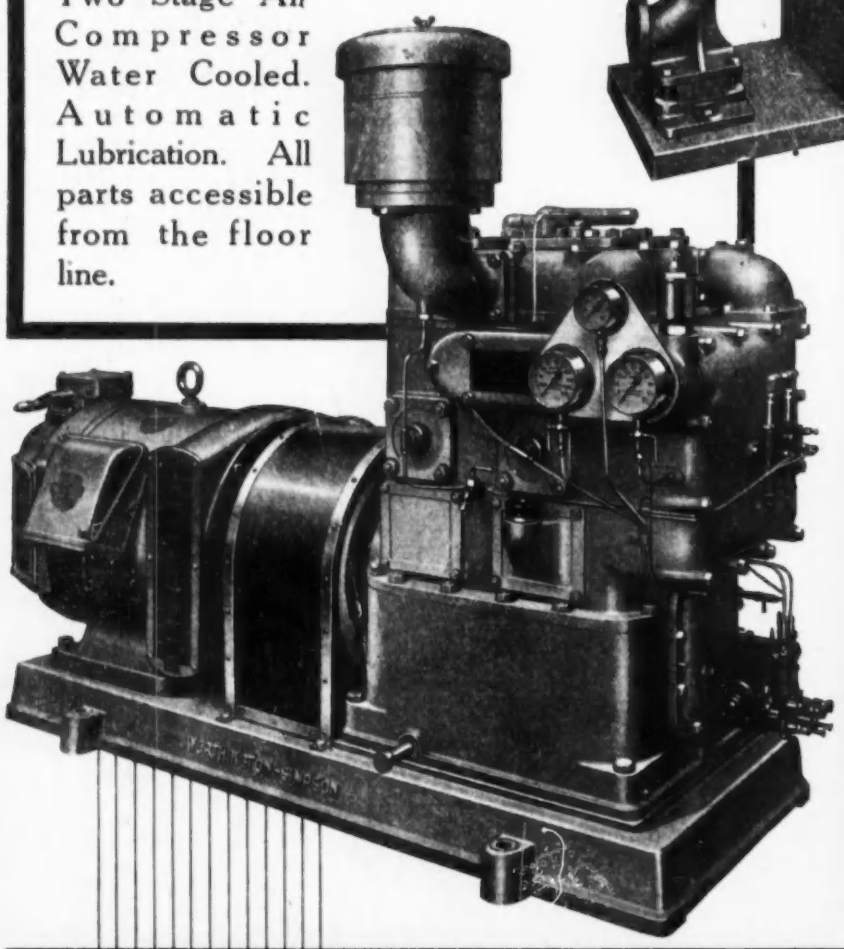

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(*Continued from page* 15.)

CONSTRUCTION OF THE TUNNEL.

BEFORE the construction of the tunnel was begun, careful geological examination of the route was carried out. Trial borings, extending to a depth of 25 m., were made over its entire length and in the ground in its neighbourhood. Below the upper layers of loose and disturbed earth the Ypres formation was met. This consists of fine sand with embedded clay layers of various thicknesses. This fine sand is rather unstable and inclined to drift. Above the Ypres layer, at three points, the Brussels formation was met. This consists of a coarser sand carrying numerous bands of sandstone, the conditions suggesting that, at some time in the past, this material had slid down from the eastern hill range into the Zenne valley. Although the presence of shifting sand in the subsoil called for special consideration in connection with the design of the tunnel structure, no doubt was felt about the possibility of making entirely satisfactory arrangements.

Fig. 9.

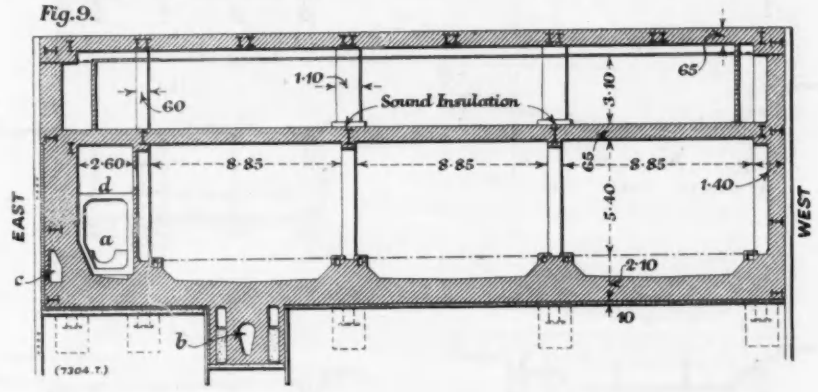
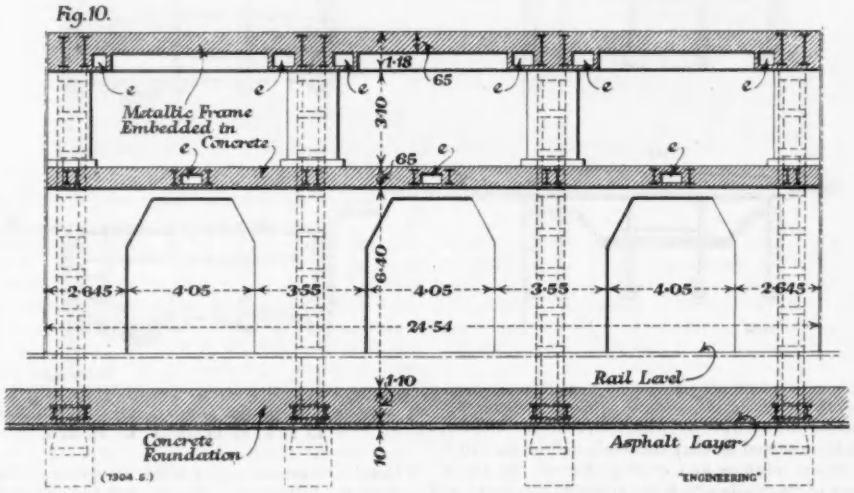


Fig. 10.



The tunnel is a steel framed structure encased in concrete of rectangular cross section, as shown in Fig. 9, on this page. It contains three main passages each having two sets of rails. The passages are separated by encased steel columns, the distance between the centres of the columns being 9·45 m. The passages are 8·85 m. wide and 5·4 m. from rail-top level to the roof. On the eastern side of the tunnel there is a main sewer, marked *a* in Fig. 9. This will deal with sewage and surface water from the higher parts of the town. The incorporation of this main sewer in the tunnel structure has eliminated the necessity for providing no less than eighteen drainage syphons below the tunnel at points where it crosses streets. Below the eastern passage there is a second sewer, marked *b* in Fig. 9. The purpose of this is to regulate the level of the ground-water table. The long impervious structure of the tunnel forms a barrier to the natural flow of the ground water from the higher ground on the east side and if no escape were provided, the water would accumulate on this side of the tunnel, resulting in the flooding of the cellars of adjacent buildings, or possibly even endangering the structures. This sewer is connected to a second longitudinal sewer *c*, by means of a series of pipe connections, this, in turn, being connected to the outside of the tunnel structure by further inclined tubes. The level of the outer ends of these external tubes is a little below that of the natural ground-water level, which varies between contour lines 26 and 29. The rails are at contour 25. In addition to its action in connection with the water table, sewer *b* also takes the tunnel drainage and has a connection to the underside of the main sewer *a*. This will enable it to deal with any leakage which may develop. This lower sewer is connected to and drains into the town sewage system at three points in the tunnel length. The main sewer *a*, which has a constant gradient of 1 in 1,000 to the south, connects to a sewer outside the railway works and empties into the River Zenne at a point close to the South Station.

It will have been noticed that Fig. 9 shows an independent chamber above the tunnel, and this chamber is also shown in the longitudinal section, Fig. 10. This is a motor garage which is being constructed over a section of the northern end of the tunnel; in other sections, the space above the tunnel is occupied by earth filling. The garage has a clear height of 3·1 m. and an area of 5,000 sq. m. Its construction will permit it to serve as an air-raid shelter in case of emergency. As will be gathered from these figures, the tunnel structure consists of a steel framework embedded in concrete. There are rows of five lattice columns across the tunnel cross-section, the rows being pitched at 7·6 m. apart in the longitudinal direction. They are connected at their upper ends by joists running both across the tunnel and longitudinally. The roof is formed by a grillage of cross joists set in concrete. The bases of the columns are set in the tunnel sole plate, which is of reinforced concrete 1·10 m. thick. The spaces between the encased side columns provide convenient niches for the installation of signal and other apparatus, and form refuges for the maintenance gang when trains are passing. The outer walls of the tunnel structure are formed by steel sheet piling which is left in place after the concrete has been run. The side niches are well shown in Figs. 13 and 14, on Plate III, of which the former is a view in a running section of a part of the tunnel nearing completion, and the latter is a view of the Chapelle Halt showing the platform under construction.

Considerable attention was given to the question of the ventilation of the tunnel. Although 2 km. is no great length for a tunnel served by steam traction, it was considered very desirable that all nuisance should be avoided. It is the intention that, in due course, the railway shall be electrified, but in the early stages steam locomotives will have to be used. In view of this, a forced and induced ventilation system is being installed. A series of ventilation cross ducts is formed in the roof of the tunnel and connects to a main longitudinal duct situated above the main sewer, as shown at *d* in Fig. 9. The cross ducts, which are fitted in the garage as well as in the tunnel, are indicated at *e* in Fig. 10. The main duct will be connected up to an air-exhausting system. Special additional arrangements will be made for the ventilation of the new Central Station, three longitudinal air ducts being provided above the platforms with cross connections designed to lead away the smoke and fumes from standing locomotives. This system will be connected up to the two exhaust fans, situated one at each end of the station. A forced-ventilation system will also be provided for this station, fresh air being supplied to ducts below the platforms from a fan situated near the centre point of the station. Fresh air for the ventilation of the tunnel itself will enter at the open ends, but for the northern section, which is the longer, a pressure fan will be installed at the Rue des Comédiens. The exhausting stations will be provided with high chimneys, largely concealed behind adjacent buildings, so that the foul air will be discharged well above street level. The whole installation is arranged so that the air flow can be reversed, should this be considered desirable, should the tunnel be used as an air-raid shelter.

The whole tunnel is being constructed on the cut and cover method, involving the excavation of a trench for the full length. In order to confine the work within the tunnel width and to avoid a trench with sloping sides, steel sheet piling has been employed. This method of working avoids the temporary cross-bracing which would have been necessary with a timbered trench, but makes it impossible to recover the piling, which remains permanently in position. Although the piling is abandoned, it has the advantage of making the whole structure more watertight, while time is saved and greater safety assured as there is no heavy timbering to be removed. To add to the life of the sheet piling it is made from copper-bearing steel and is heavily tarred on the outside.

The construction of the tunnel may be divided into ten stages; these are illustrated in Figs. 11*a* to 11*j*, on page 22. The cross-sections shown are at a point where the tunnel carries the superimposed garage. The first stage, Fig. 11*a*, covers the demolition of the buildings on the site and the opening of a shallow trench. In the second stage, Fig. 11*b*, the sheet piling is driven and the centre part of the surface trench is carried deeper but is kept above the original ground-water table indicated by the chain-dotted line *w t*. The lengths of piles range from 18 m. to 22 m.; they are driven to a depth of from 7 m. to 9 m. below the position which will be occupied finally by the sole plate of the tunnel. The third stage of the work, shown in Fig. 11*c*, covers the lowering of the ground-water level by means of percolation sumps, after which the pits *g*, *h*, *i*, *j*, *k* are sunk. These are timbered and are provided with sheet-iron casings at their lower ends. This stage also covers the reinforcement of the upper end of the sheet piling on the east (right) side, which is exposed to the greater pressure, by means of longitudinal girders *y*.

In the fourth stage of the work, Fig. 11*d*, the five lattice columns, forming the main vertical members of the tunnel structure, are erected in the pits, the lower ends being set on concrete bases

formed by filling the sheet-iron casings. The bottoms of the columns are 8 m. below the bottom of the trench at this stage. The next procedure, forming stage five and illustrated in Fig. 11*e*, covers the placing of the main cross girders forming the roof of the garage and the centre portion of the corresponding girders forming the roof of the tunnel, the ends of the upper girders and the tops of the outer columns being secured to the steel by fixing and wedging the longitudinal members *m* and *n*. The lower parts of the pits are then filled with concrete securing the vertical columns in position. In the sixth stage, Fig. 11*f*, the excavation is levelled off to the depth reached for the middle portion in the fifth stage and the tunnel-roof girders are completed. Further longitudinals, *p* and *q*, securing the steel structure to the piling, are fitted. A view at this stage is given in Fig. 15, on Plate III, which shows the upper ends of some of the lattice columns with the upper cross beams and the cross-members forming the tunnel roof in course of erection.

The seventh stage, Fig. 11*g*, covers the deepening of the excavation and the fitting of temporary cross girders *x z*. Much of the excavation before the fixing of these girders was carried out by a steam shovel. This operation is illustrated in Fig. 16, on Plate III. The earth excavated from the tunnel was carted away to be used as filling for raising the level of the North and South Stations. Fig. 17, Plate III, illustrating the excavation at a rather later stage, shows a motor lorry being loaded to transport the spoil to the South Station. In the next, eighth stage, Fig. 11*h*, excavation is completed to the full final depth and the lower row of cross girders is fixed. These are ultimately embedded in the concrete sole plate of the tunnel. The trench for the sewer *b* below the tunnel is also dug. This operation is illustrated in Fig. 19, on the opposite page. In the ninth stage, Fig. 11*i*, the concrete work of the sewer and the lower part of the tunnel up to the temporary cross girders *x z* is completed. This is followed by the tenth stage, Fig. 11*j*, in which the temporary cross girders are removed and the concreting work of the tunnel, air duct and sewers is completed. A view of the south portal of the tunnel is given in Fig. 18, on Plate III. The Chapelle Halt lies immediately adjacent to this portal.

The work in connection with the construction of the Central station is being carried out generally on the same lines as that for other sections of the tunnel, but, owing to the much greater width involved, various modifications in design and procedure have had to be introduced. The overall width of the tunnel is 35 m., but that of the station is 60 m. A general view, showing the construction of the station, is given in the aerial photograph reproduced in Fig. 12, on Plate III. The clear width between the main columns, separating the two-track passage ways, is 8·85 m. in the tunnel, as shown in Fig. 9. In the station section each of these ways has to accommodate a platform 8 m. wide between the two tracks. In view of this increase to a span of 16·85 m., rows of intermediate columns, rising from the platforms, have been placed between the main columns. Owing to the great width of the station, it was not found practicable to drive the two rows of external sheet piling and brace them together by cross-girders in the manner shown in Fig. 11*e*, and the outer part of the eastern tunnel way, with the lower sewer, is accordingly being constructed between two rows of sheet piling. The outer of these, lying against the eastern side of the completed structure, will remain in the ground. The other row of piling, which will extend up to ground level, will remain in position until the concrete work on its outer side is completed. When the earth has been excavated on the other side, the piling will be cut off at the level of the tunnel floor. The completed sewer and other concrete work will then act as a retaining wall while the remainder of the station structure is built.

When the tunnel is completed, portions of the route will be built over. As it would have added seriously to the cost to construct the whole of the tunnel roof sufficiently strong to carry buildings, an arrangement has been come to with the municipal building authorities by which any future buildings will be designed so that the loads will be carried by the main columns and cross-girders of the tunnel. Notes of the loads which the columns can carry will naturally be kept in the railway records, but in order to prevent the possibility of their being overloaded by builders who have not made proper inquiries, copper plates giving the necessary information are being fixed to the tops of the columns. These will be exposed as soon as a site is cleared for building purposes. In order to minimise the propagation of sound and other vibrations from the tunnel to the buildings above, layers of lead and asbestos have been inserted between the tops of the columns and the road slab, and in other positions.

(To be continued.)

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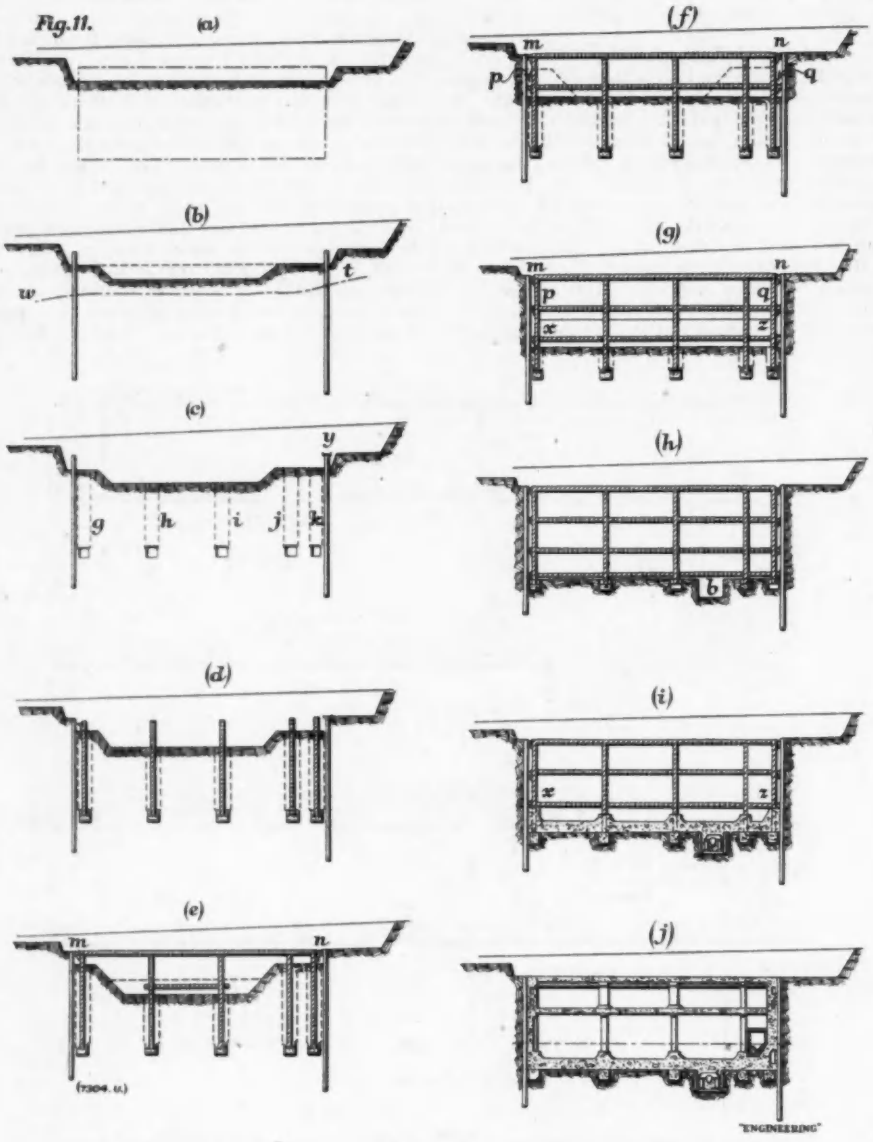

DRAGLINE EXCAVATOR ILLUSTRATIONS.—The paper on "The Dragline Excavator," read before the Institution of Civil Engineers by Mr. W. Barnes, M.I.Mech.E., and reproduced in abridged form in ENGINEERING, vol. 149, page 571, *et seq.* (1940), was illustrated, when it was delivered, by a larger number of views than it was possible to reproduce in the paper as published by the Institution or in our abridgment. Messrs. Ruston-Bucyrus, Limited, Excavator Works, Lincoln, inform us that these additional views, 35 in all, have been issued in a booklet supplementary to the paper and that a limited number of the booklets are available for those who are interested in the dragline excavator and its capabilities.

LITERATURE.

Thorpe's Dictionary of Applied Chemistry. Fourth edition. Volume IV. *Digallic Acid to Feeding Stuffs.* By SIR JOCELYN FIELD THORPE and DR. M. A. WHITELEY. London: Longmans, Green and Company, Limited. [Price 70*s.* net.]

By the death of Sir Jocelyn Thorpe, on June 10, the chemical world has lost a distinguished personality, who had taken a prominent part in both educational and scientific affairs. He will be remembered as an eminent professor, a gifted teacher, and an original research worker, notwithstanding the demands made on his time by national organisations. He was notable for his charm of manner, as well as for his ability to take up new ideas and stimulate others to put them into practice. The volume under review was his last completed work and is a valuable addition to a dictionary which is international in its scope.

A feature of the present volume is the monograph on explosives, contributed by the late Mr. H. Shankster. This is a comprehensive survey of the subject, covering a wide field, including nitrohydrocarbons, nitrophenols, nitricesters, smokeless powders and initiatory explosives. The tests applied in the examination of explosives are discussed, particular attention being given to the procedure adopted in determining the sensitivity to percussion, friction and heat, power and stability, the latter being

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(For Description see Opposite Page).

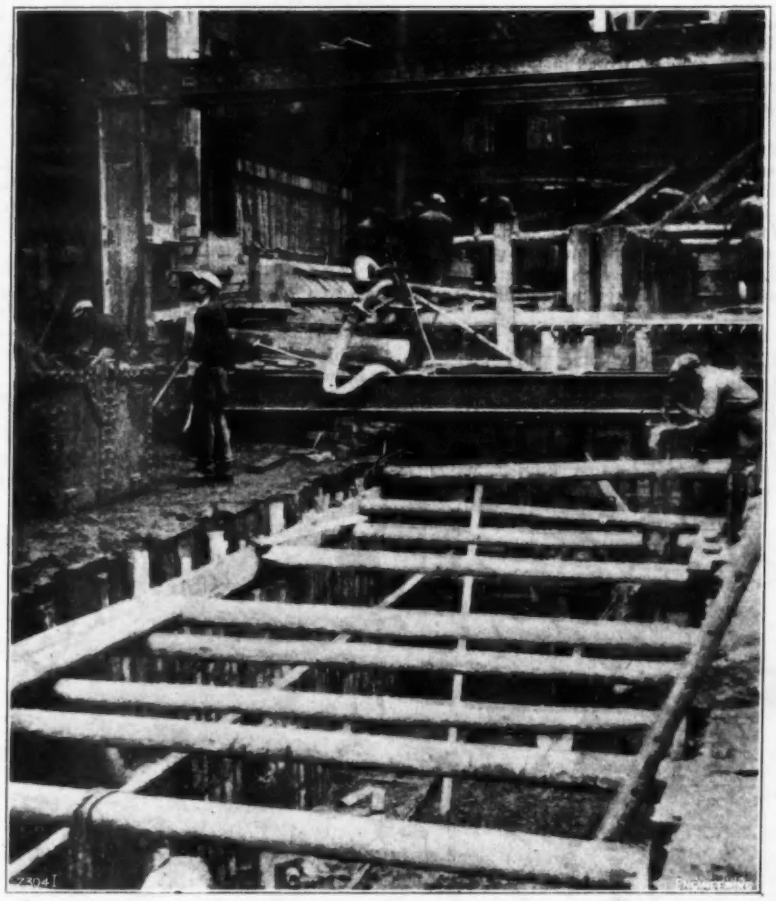


FIG. 19. TRENCH FOR LOWER SEWER.

especially important so far as propellants are concerned. Mr. T. J. R. Alexander deals with recent developments relating to explosives for collieries. The section devoted to dust is mainly confined to the accidental production of dust, protection against it, and its relation to dust explosions. Experiments carried out on the physiological effects of dust show that some 75 per cent. of the dust breathed is swallowed, the remaining 25 per cent. passing to the respiratory system. Of the dust inspired, some 40 per cent. to 60 per cent. is retained, the dangerous particles being those of 1 to 2 microns in size. A member of the Dyestuffs Group of Imperial Chemical Industries, Limited, has contributed the monograph on the azodyestuffs, in which the author deals with the preparation of the azodyes by the diazotisation and coupling reactions, and gives a survey of the more important azodyes. The constitutions of more than 600 different azodyes have been published, many of them being manufactured by a number of firms and appearing on the market under a variety of trade names. This class of dye now constitutes about one half of the total number of synthetic dyestuffs manufactured.

Mr. A. King, of Imperial College, deals with various aspects of emulsions. Owing to the great industrial importance of emulsions, their preparation on a large scale has been the subject of much study and many mechanical devices have been used for the purpose. The opposite process, the separation of emulsions into their different phases, now offers many technical problems in the crude petroleum, and gas-tar industries as well as in the preparation of butter from cream. One of the earliest uses of emulsions was in the control of insect pests on plants, for which purpose pure oil could not be used because of its destructive action on the foliage. At the present time, emulsions play an important role in the textile, asphaltic bitumen, leather and paint industries. Dr. J. J. Sudborough gives an admirable exposition of esterification from the standpoint of physical chemistry. Throughout the volume references to more specialised treatises and to original papers are given.

Elasticité et Photoélasticimétrie. By H. LE BOITEUX and ROBERT BOUSSARD. Paris: Hermann et Compagnie. [Price 180 francs].

IT is a melancholy reflection that the calm and detached atmosphere of pure science in which this book must have been conceived has been so rudely disturbed by the events of the past few weeks, and that the very press from which it emanated, if still functioning, is doing so under the shadow of an alien domination; but the hope that this state of affairs may be of short duration sufficiently justifies a review of the book, even though it is improbable that copies will be available to the general public until the soil of France is once more restored to its rightful owners.

The photo-elastic method of investigating the stress distribution in loaded structures is based upon Brewster's observation, early in the Nineteenth Century, that certain transparent materials, optically isotropic when unstressed, become optically anisotropic under stress, but the practical application of the method has been developed almost entirely during the past thirty years, and has been due largely to the work of Professor E. G. Coker, F.R.S., many of whose results have been recorded from time to time in ENGINEERING. Many other scientists in various countries, however, have contributed to the present state of knowledge of the subject, and the clear presentation of the principles and practice of photo-elasticity by Messrs. Le Boiteux and Boussard provides a useful survey of the results of their collective researches. It is divided into four parts, the first of which contains an admirably concise exposition of the mathematical theory. The second is devoted to the optics of isotropic and anisotropic media, and covers all the usual auxiliary optical components employed in photo-elastic work. The third section treats of the theoretical basis of photo-elasticity proper, and the experimental procedure adopted in its investigation; while the concluding part discusses in detail the methods that have been devised to determine the direction and magnitude of the principal stress components at any point within the plane of the model. Both as a source of reference and as a laboratory manual, the work may be commended, and it is to be hoped that an improvement in European circumstances may eventually render it more freely available than is the case at present.

Vapor Charts and Special Tables for Turbine Calculations. By FRANK O. ELLENWOOD and CHARLES O. MACKEY. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

SINCE the numerical values for the thermodynamic properties of steam have long been well established, the main justification for a fresh publication of the data must reside in their presentation in a form that is more convenient for use than those previously available. With this consideration prominently in mind, the authors of this collection of vapour charts, both of whom are professors of heat-power engineering in Cornell University, have chosen the graphical, in preference to the tabular, form, the charts being sub-divided into many parts and bound into a book of about quarto size. The steam charts are drawn with enthalpy, *i.e.*, total heat, as ordinates and specific volume as abscissæ, the volume scale being logarithmic for compactness and covering the range from 0·05 cub. ft. to 3,500 cub. ft. per lb. Temperatures range from 1,200 deg. to 32 deg. F., and pressures from 5,500 lb. per square inch down to 0·18 in. Hg, absolute pressures below 1 lb. per square inch being given in inches of mercury. To meet the highest pressures now encountered in steam generators and feed pumps, an entirely new chart has been prepared, relating the pressure, enthalpy, specific volume and entropy of water, at temperatures below the critical and pressures up to 6,000 lb. per square inch. For use in turbine design, the authors include tables showing the jet velocities from an ideal nozzle over the range of available energy up to 600 B.Th.U. per lb., while other tables giving squares of numbers and corrections to barometric readings will be found of general utility in thermodynamic problems.

The already considerable scope of the data is extended to refrigeration and ventilation by the inclusion of thermodynamic charts for ammonia and dichlorodifluoromethane (Freon-12) and of psychometric charts for mixtures of air and water vapour. The latter are largely based on work in which Professor Mackey collaborated, and might perhaps have been usefully accompanied by the "comfort chart" of the American Society of Heating and Ventilating Engineers. Otherwise, there is little to criticise in this excellent compilation and it can be strongly recommended to engineers, lecturers and students.

LUBRICATION OF AGRICULTURAL TRACTORS.—It is important in these days when a large proportion of unskilled labour is taking charge of agricultural and other tractors, to ensure that the work of these machines is not interrupted by want of attention. Messrs. David Brown Tractors, Limited, Meltham, near Huddersfield, have, therefore, prepared a thoroughly practical chart showing how their tractors should be lubricated. The centre of the chart is occupied by a bold diagram of the tractor with all the points which require attention clearly identified by numerals. Surrounding the diagram are photographic views of each of the points, each view being numbered to correspond with its position on the diagram. As the views show exactly the various grease-gun nipples, plugs, etc., which are to be lubricated, surrounded by a white circle and are accompanied by explanatory instruction, no omissions or mistakes are likely to be made. A table shows the maximum permissible periods between the lubrication of each point. One of the tractors was described and illustrated in ENGINEERING, vol. 148, page 73 (1939).

CREEP UNDER COMBINED TENSION AND TORSION.

PART I.—THE BEHAVIOUR OF A 0·17 PER CENT. CARBON STEEL AT 455 DEG. C.

By H. J. TAPSELL, A.C.G.I., A.M.I.Mech.E., and A. E. JOHNSON, M.Sc.

IN practice, engineering structures are sometimes subjected to complex stress systems at high temperatures. These complex stress systems can, in all cases, be expressed in terms of an equivalent system of a simple tension stress combined with a simple torsion stress. Thus the general problem of creep under complex stress systems is most simply studied by investigations of the creep behaviour of test specimens subjected to various combinations of tension and torsion stresses. Much work has been done on the kindred problem of the failure of materials under combined stresses at air temperature. In such cases, the investigators have been interested in criteria of failure of the material as expressed by the yield point or the fatigue limit. At high temperatures a similar problem presents itself except that, instead of a definite criterion of failure being available an arbitrary criterion, such, for example, as a specified rate of creep in the direction of a principal stress, must be used. The use of such a criterion makes it possible to investigate the nature of the laws underlying the creep behaviour. Most of the work of other investigators has been of a theoretical nature. Theories have been advanced by F. K. Odqvist,* R. W. Bailey,† J. J. Kanter,‡ C. R. Soderberg,§ J. Martin,‖ and A. Nadai,¶ in most cases based on the results of tensile creep tests. Bailey, however, carried out a series of tension, torsion, and combined-stress creep tests on a 0·115 per cent. carbon and a 0·45 per cent. carbon steel at 480 deg. C., and also creep tests on lead tubes under internal pressure and superimposed axial loading.

The authors considered that further experimental evidence was necessary to determine, if possible, which of the existing theories was correct, or, if none adequately explained the experimental data, to develop a more applicable theory. From a practical point of view it was felt that information regarding the rates of creep produced by combinations of tension and torsion stresses should be provided for the commonly-used commercial materials. It was, therefore, decided to commence work, in the Engineering Department of the National Physical Laboratory, on a 0·17 per cent. carbon steel at 455 deg. C. (approximately 850 deg. F.). The present paper deals with the first part of a programme of work planned to include some other commercial materials and to give information concerning the effect of test temperature. The nomenclature employed is as follows:—

Applied tensile stress	t
Applied torsion stress	s
Major principal stress	p_1
Major principal stress (in pure tension)... ...	P
Secondary principal stress	p_2
Minor principal stress	p_3
Creep strain in direction of major principal stress	e_1
Creep strain in direction of secondary principal stress	e_2
Creep strain in direction of minor principal stress	e_3
Axial creep rate	C_a
Circumferential creep rate	C_c
Creep rate in direction of major principal stress	C_1
Creep rate in direction of secondary principal stress	C_2
Creep rate in direction of minor principal stress	C_3
Time	T
Angle between direction of major principal stress and axis of tube	ϕ

Particulars of Steel and Form of Specimen.—The 0·17 per cent. carbon steel, from which test specimens were machined, was in the form of hot-rolled bars 1½ in. in diameter. It had been produced in a basic open-hearth furnace, its percentage chemical composition being as follows:—Carbon, 0·17; manganese, 0·72; silicon, 0·20; sulphur, 0·024; and phosphorus, 0·022. Before machining test specimens from the material, one of the bars was cut into 6-in. lengths, which were heated for ½ hour at 950 deg. C., and then air cooled. Although towards the end of the experiments it was felt that it may have been advantageous to extend the scope of the tests, it was considered inadvisable to prepare additional specimens from a new bar of material heat-treated similarly to the former material. The tubular test specimen was of the form shown in Figs. 1 and 2, on this page. It was 0·5-in. in internal diameter and had a wall thickness of 0·021 ± 0·0005-in. over a 2-in. parallel portion. In making a specimen, a blank was first machined down to within $\frac{1}{32}$ in. of the largest diameter, after which the specimen was drilled through. The ends of the specimen were then turned down to size and the centre portion reduced by light cuts to $\frac{11}{32}$ in. diameter. The specimen was bored to within 0·0005 in. of finished size and one end was internally screwed. Final machining and polishing of the central portion was carried out with the specimen on a mandrel, and keyways were cut in the ends. The specimen was finished by lapping the hole to the correct size. Measurements of the external diameter and of the wall thickness of each specimen before test were made at numerous positions along the parallel portion.

Fig. 1.

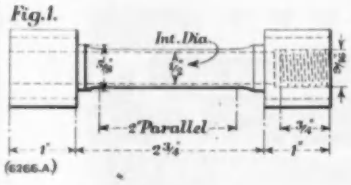


Fig. 2.

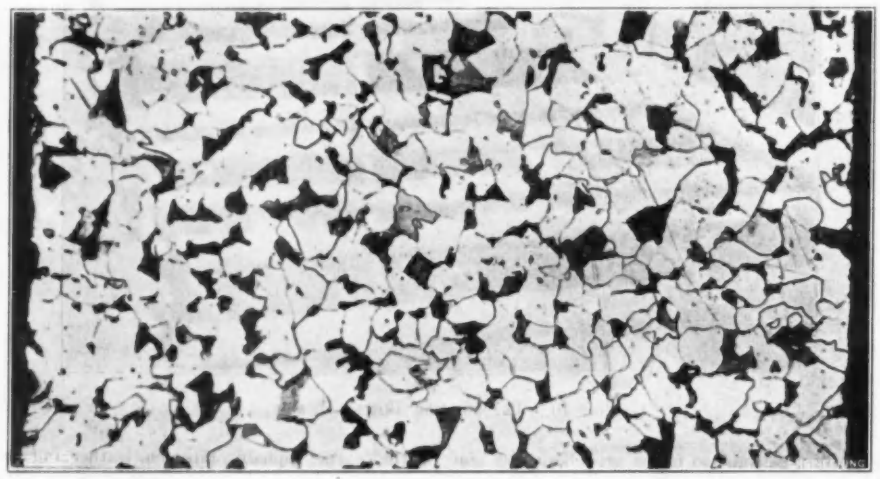


FIG. 3. TRANSVERSE SECTION OF WALL OF TEST PIECE. × 250.

It was appreciated that during tests at 455 deg. C. the specimens would oxidise to some extent, and at the outset a measure of the degree of oxidation was obtained by suspending pieces of the steel in a furnace maintained at 455 deg. C. and extracting a piece at intervals up to about 150 hours. Further, some tubular specimens, which had been used in the creep tests lasting 150 hours, were sectioned, and measurements were made of the wall thickness at several positions under a microscope. These measurements showed that about 0·001 in. thickness of metal from the tube wall was lost by oxidation after about 20 hours heating at 455 deg. C., and that little further oxidation occurred up to the end of a creep test of 150 hours duration. Since in each creep test the specimen was heated up overnight and took 24 hours to reach a correct steady temperature, the wall thickness throughout each test was assumed as being 0·001 in. less than the measured initial thickness. Sections of some of the tube walls were also examined after polishing and etching in a dilute solution of nitric acid in alcohol. A microphotograph of a transverse section of a tubular specimen after test at 455 deg. C., at a magnification of 250 diameters, is given in Fig. 3, on this page. It shows the grain size in relation to the thickness of the tube wall, the uniformity of grain size across the section, no evidence of decarburisation near the wall surfaces, and a normal structure.*

Description of Test Apparatus.—The investigation involved the design of a combined tension and torsion creep-testing machine; two such machines have been constructed. A photograph of one of the machines is reproduced in Fig. 4, opposite, and various details are illustrated in Figs. 6, 7 and 8. From a ball pivot (*a*, Fig. 5), at the top of the framework of the machine, is suspended a tension bar, which is prevented from rotation by the attachment of a cross-bar *b*, having freedom of movement vertically in slots cut in channels attached to the frame of the machine. The tension bar carries a tubular stainless-steel adaptor *c*, and the test specimen is held in the adaptor by a split ring collar. A similar adaptor fits the lower end of the specimen. The keyways cut in the enlarged ends of the specimen fit keys carried in the two adaptors. Axial load can be applied to the specimen through a universal joint *d* and tension bar attached to the lower adaptor. This tension bar is provided with a torque arm *e* 8 in. long, having wooden end pieces curved to a radius of 4 in. Fine-gauge steel wires are attached to the wooden end pieces, pass round their peripheries, and then over practically frictionless pulleys to scale pans. An electric furnace surrounds the specimen, the temperature of which can be maintained within ±2 deg. C. of 455 deg. C. The temperature gradient over the effective gauge length of the specimen is kept within ±3 deg. C. of the mean temperature. Details of the adaptor ball support are shown in Fig. 6, of the specimen seating in Fig. 7, and of the universal joint in Fig. 8.

The measurement of axial and circumferential creep simultaneously and independently is achieved by the use of the combined tension and torsion strain meter (seen at *f*, Fig. 5) and shown in Fig. 9, opposite. The lower adaptor tube is cut away over an angle of 120 deg. at back and front, and the strain meter is supported in the space thus provided. The strain meter consists of a steel rod *a*, ⅜ in. in

* See "A Theory of Creep under Combined Stresses." "Plasticitetsteon," Royal Swedish Inst. Eng. Research, Stockholm, 1934. See also *Proc. Fourth International Congress of Applied Mechanics*, page 228 (1934).

† See "The Utilisation of Creep Test Data in Engineering Design," *Journ. Inst. Mech. Eng.*, vol. 131, page 131 (1935). See also ENGINEERING, vol. cxl, pages 595, 647 (1935).

‡ See "The Interpretation and Use of Creep Results," *Journ. Am. Soc. Metals*, vol. 24, page 870 (1936).

§ See "The Interpretation of Creep Tests for Machine Design," *Trans A.S.M.E.*, vol. 58, No. 8, page 773 (November, 1936).

‖ See "Design of Members Subjected to Creep at High Temperatures," *J. App. Mechs.*, vol. 4, No. 1 (March, 1937).

¶ See "On the Creep of Solids at Elevated Temperatures," *J. App. Phys.*, vol. 8, No. 6 (June, 1937).

* Longitudinal sections showed similar characteristics with no evidence of directional properties in the steel.

CREEP OF STEEL UNDER COMPLEX STRESS SYSTEMS.

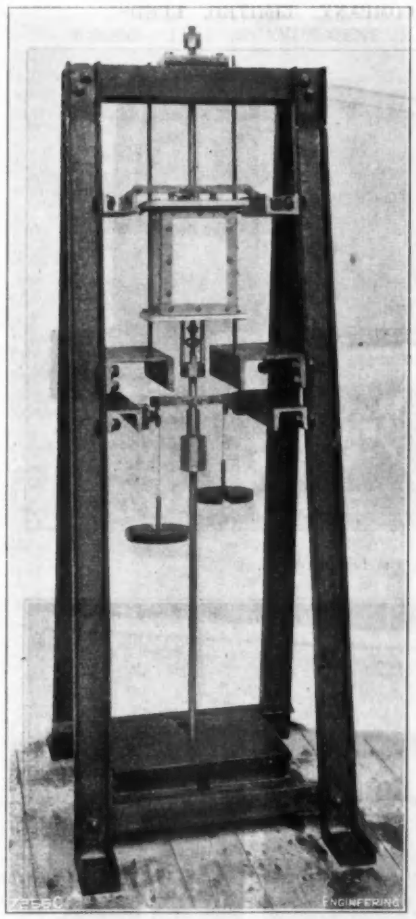
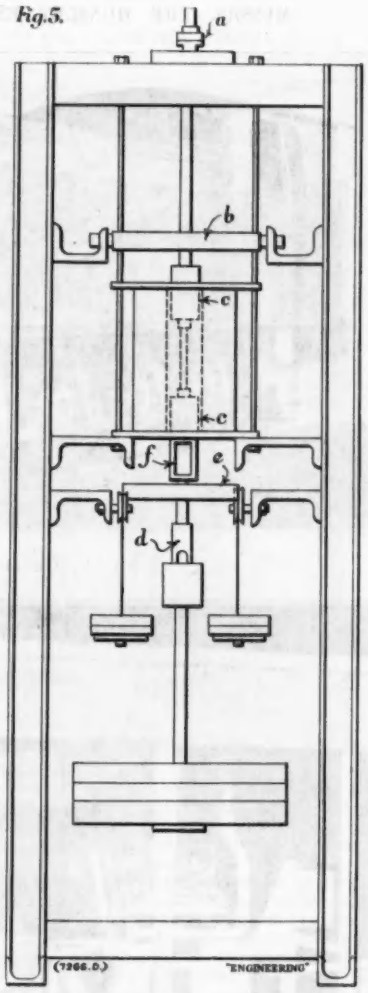
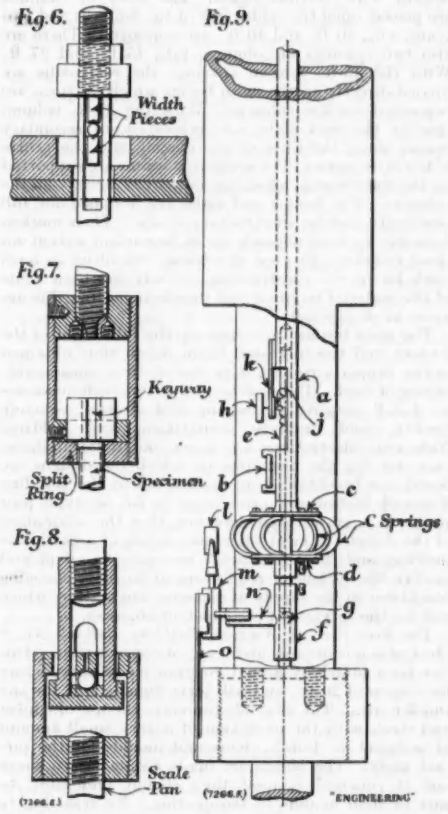


FIG. 4. COMBINED-STRESS CREEP-TESTING MACHINE.





diameter, which is screwed into the top end of the tubular specimen (not shown in Fig. 9). This rod is drilled to a bore diameter of ¼ in. at its lower end and a sector of 120 deg. is cut away from one side. It holds a reference mirror *b*, and is attached to a thin horizontal disc *c*, 1 in. in diameter. A second disc *d* is attached to the first through four "C" springs. A rod *e*, ⅛ in. in diameter, which slides in the upper rod *a*, is attached to the lower disc *d* and to a tube *f*, which turns on an internal pivot *g* fixed to the base of the adaptor. Axial creep is measured by means of a mirror *h*, supported by a rhomb *j*, 0·174 in. in diameter, which is held between a clip *k* sprung from the rod *a* and one of the circumferential grooves in the rod *e*. The movement of the mirror is determined by a telescope and scale at a distance of about 60 in., and 1 in. of scale movement corresponds with 0·000157 in. per inch of axial strain of the test specimen.

Circumferential creep is determined from the relative movements of the torsion mirror *l*, and the reference mirror *b*. The latter mirror provides a means of measuring the twist of the top end of the specimen when torsion load is applied to the scale pans. The torsion mirror *l* is attached to a rhomb *m*, 0·313 in. in diameter, which is held between a knife edge support *n*, attached to the pivoted tube, and one of a number of grooves in the spring support *o*, which is fixed to the adaptor. The pivoted tube is held against the pivot by the pressure of the "C" springs. Movements of the mirrors *l* and *b* are observed by telescope and scale at a distance of about 30 in., and 1 in. of relative scale movement corresponds with 0·000148 in. per inch of circumferential strain. The combined tension and torsion meter was calibrated by tests at air temperature on a tubular specimen of spring steel having a wall thickness of 0·01 in. It was found that neither the tension nor the torsion calibration was affected by the addition of torsion or tension loads, respectively, during the calibrations, thus showing that the strain meter is capable of measuring tension and torsion strains independently.

Experimental Work.—Only one creep test was carried out on each specimen. The test lasted about 150 hours, readings of creep strain being made at frequent intervals during the first day and thereafter at daily intervals. As far as possible, stresses were chosen to give a range of creep rates in the direction of maximum principal stress varying between 10^{-6} in. and 10^{-7} in. per inch per hour. This range of creep rates corresponds to the linear portion of the log. stress-log. creep rate relation, expressed in the form

$$\text{creep rate} = \text{constant} \times (\text{stress})^n.$$

The creep rates in the three directions of principal stress were computed from the measurements of axial and circumferential creep by means of the formulæ* :—

$$C_1 = C_a + \frac{C_c}{2}\left(\sqrt{\left(\frac{t}{2s}\right)^2 + 1} - \frac{t}{2s}\right)$$

$$C_2 = C_a - \frac{C_c}{2}\left(\frac{t}{2s} + \sqrt{\left(\frac{t}{2s}\right)^2 + 1}\right)$$

$$C_3 = C_c\frac{t}{2s} - 2\,C_a.$$

Seven pure-tension tests were performed in order to determine the characteristic constants of the material with sufficient accuracy. In view of the cost of the tubular specimens, some of these tests were made on solid specimens. Tests at 6 tons per square inch on both solid and tubular specimens gave results which agreed very well, and a test at 6·15 tons per square inch on a tubular specimen also gave results in conformity with other tests on solid specimens. These tension creep tests provided evidence of good uniformity in creep properties among the specimens. In addition to the tension tests, three pure-torsion tests were made and also two tests under combined tension and torsion stresses at each of the following ratios of torsion to tension stress, namely, 2·0, 1·0, 0·5 and 0·172.

(To be continued.)

* For the derivation of these formulæ, see Appendix I.

WAR-TIME BUILDING CONSTRUCTION.

THREE further bulletins dealing with war-time building construction have now been published by H.M. Stationery Office. The three bulletins previously published were reviewed on page 604 of our issue of June 21, 1940. The price in each case is 1*s.* net.

The first of the new publications, *Wartime Building Bulletin No.* 4, contains a range of roof types supplementary to those given in Bulletin No. 1, which, it may be remembered, dealt with the steelwork of single-storey open-shed factories. The new designs, suitably combined with others in the factory structure, will, it is claimed, facilitate camouflage. The principal difference between the two types of structure lies in the roof glazing. In the first case, the glazed areas were placed vertically on the roof trusses, while in the supplementary designs the roof and glazing are sloped and the roof trusses are of symmetrical, double-pitched design. Working drawings of the steelwork are available as before to those engaged on the erection of factories for a government department and may be obtained on application to the Iron and Steel Control. An appendix describes a daylight-factor protractor with which it is possible to obtain very rapidly an estimate of the amount of daylight entering a factory and to determine the best location for the glazing. Such protractors can be obtained, at the price of 3½*d.*, from the Director of the Building Research Station, Watford.

Wartime Building Bulletin No. 5 is supplemental to *Wartime Building Bulletin No.* 2, which contained some general notes on the use of reinforced concrete. It comprises a number of designs to serve as examples of the application of this material to the specific problems of a factory where a large area, unobstructed except by columns, has to be enclosed.

Particular attention has been paid to economy in steel, and the buildings consist of reinforced-concrete roof slabs with a raised section providing a continuous lantern with vertical lights. The rows of columns are placed along the centre line of the lanterns and two spans, viz., 30 ft. and 40 ft., are employed. There are also two spacings of columns, viz., 15 ft. and 27 ft. With the 15-ft. column spacings the roof slabs are carried directly on the main beams which, in turn, are supported on the columns. With the 27-ft. column spacing the roof slabs are supported on secondary beams along the lines of the glazing and the centre of the main beams. The secondary beams are supported on the main beams, which are supported directly on the columns. The beams and slabs are designed for full continuity and for construction *in situ*. Their marked economy in steel depends to an important extent on these features. In view of present difficulties in form work for *in situ* construction, a study has been made of the material required and details regarding this are given in an appendix.

The main beams are carried up the full height of the lantern and the increased beam depth thus obtained at the supports results, it is stated, in a considerable saving of steel. The *Bulletin* also covers such questions as A.R.P. conditions, loading and stresses, concrete quality, roof drainage, foundations and lighting. Numerous illustrations are given, but detailed drawings showing the principles on which the designs are based can be obtained on application to the Building Research Station, the price being 2*s.* 6*d.* per type, post paid. It is emphasised, however, that the adaptation of the designs to meet the requirements of a particular building and the adjustments necessary to adapt and modify the system of reinforcement to meet changing conditions in the supply of material, are matters which call for the services of a competent engineer.

The first part of *Wartime Building Bulletin No.* 6 illustrates a centreless arch type of construction. This has been found by actual erection to be satisfactory for a span of 20 ft., and will serve equally well for any smaller span. The method eliminates the use of timber and steel, with the exception of a very small amount of material for lintels, doors and moulds for the precast units. The blocks are made accurately to shape and if concrete is used they should preferably be cast in steel moulds to ensure this. By resorting to vibratory methods of placing, and by the use of suitable mixes, the blocks can be quickly removed from the moulds and produced rapidly. They require no reinforcement. The units are simple to make, the moulds are not complicated and it should be within the capacity of any concrete-products manufacturer or building contractor to turn out the units. They have been made at the Building Research Station for the 20-ft. arch in a dry mix and tamped by vibration, removed from the moulds immediately, and erected when one day old.

The second part of the *Bulletin* is a supplement to *Wartime Building Bulletin No.* 3 and gives details of two designs which were only briefly referred to in the earlier publication. The application of three type designs to multiple plan hut schemes is also shown.

DIESEL LOCOMOTIVE FOR TRINIDAD GOVERNMENT RAILWAYS.

ACCORDING to the current issue of a reliable reference book, the Trinidad Government Railways have, on their 150 miles of open track, 30 steam locomotives and one steam railcar. It would appear, therefore, that the 0-8-0-type Diesel mechanical locomotive shown in Figs. 1 and 2, on this page, is the first of its class. It is, we are informed, the largest and most powerful Diesel locomotive having mechanical transmission so far constructed in this country. The engine has been built by Messrs. The Hunslet Engine Company, Limited, Jack-lane, Leeds, 10, the design being evolved in close co-operation with the Crown Agents for the Colonies, London, and the chief mechanical engineer of the Trinidad Government Railways. The general construction of the locomotive will be clear from Fig. 1. The wheel-base is 12 ft. 9 in., the length over the buffer beams 27 ft. 7½ in., and the weight, in working order, 34 tons 18 cwt. The gauge is the standard 4 ft. 8½ in. Conspicuous features of external design are the large radiator and the roomy and well-ventilated cab, both of which are rendered necessary by the tropical conditions in which the locomotive has to operate. The wheels are driven by a cranked jackshaft situated under the cab, and the coupling rods are of the linked type.

A view of the main engine and auxiliaries is given in Fig. 2, the bonnet sides being removed. The main power unit is a six-cylinder four-stroke cycle Diesel engine of the Paxman-Ricardo RZ type, with cylinders of 6¾ in. bore by 10 in. stroke. It is capable of developing 277 brake horse-power on a 1-hr. rating at 1,000 r.p.m. The engine follows Messrs. Davey, Paxman's general practice, having a deep bedplate carrying the main bearings and surmounted by "A" frames supporting the cylinder blocks; the bedplate is hidden by the locomotive frame in Fig. 2. The large cover seen just above the frame gives access to the crankcase, and its removal enables the pistons and connecting rods to be withdrawn and the main bearings to be reached. The frames and bedplate are coupled by through-bolts of high-tensile steel to take the firing stresses. The interchangeable cylinder liners are of wear-resisting cast iron and are of the wet type inserted at the top with the the lower end free to expand. The cylinder heads are also interchangeable and are of Messrs. Davey, Paxman's Ricardo "Comet Head" type. As they are spigoted into the top of the cylinder liner, they are clear of the cylinder block. The cooling water from the liners flows directly to the heads. All engine bearings, including both ends of the connecting rod, are pressure lubricated from duplicate gear-type oil pumps, the oil system being provided with a large Auto-Klean self-clearing filter. The oil is cooled in a portion of the radiator, which is fitted with 12 Serck interchangeable cooling elements that can be quickly removed and replaced. Special attention has been given to the filtering of the air and also the fuel oil.

Although the main engine fitted can be readily started from cold in normal circumstances, as, for instance, when used as a stationary power unit, it is particularly important in this locomotive that positive instantaneous starting shall be effected at all times. The starting gear, therefore, consists of a Ford V 8 petrol engine, itself electrically-started. This engine is seen to the left of Fig. 2, and is capable of developing 90 h.p. at 4,000 r.p.m. It has push-button control from the cab and operates, through a Bendix gear, a geared ring on the flywheel of the main engine, which it is capable of motoring round for any length of time. This arrangement ensures a start under the most difficult circumstances and the delays which would otherwise result from failure to start promptly are eliminated. The engine is, of course, of the non-reversing continuously-running type, reversal of the locomotive and its speed variation being effected by the transmission gear. This gear consists of a Vulcan-Sinclair hydraulic coupling followed by Messrs. Hunslet's auxiliary gear-change clutch and their four-speed constant-mesh gearbox, the latter giving locomotive speeds, in both directions, of 5½ m.p.h., 8½ m.p.h., 12½ m.p.h. and 18½ m.p.h.

This control is now adopted as a standard on all high-power Hunslet Diesel locomotives and includes the firm's pre-selective gear change. It is very readily manipulated, as a single handwheel not only speeds up the engine but also controls the gears, the several actuating movements being effected through a series of cam-operated valves, which deliver air at a pressure of 50 lb. per square inch to the cylinders controlling the gears, clutch and clutch-shaft brakes, the movements being automatically made in the correct sequence. The control wheels and all other locomotive handling

0-8-0 TYPE DIESEL LOCOMOTIVE FOR TRINIDAD.

MESSRS. THE HUNSLET ENGINE COMPANY, LIMITED, LEEDS.

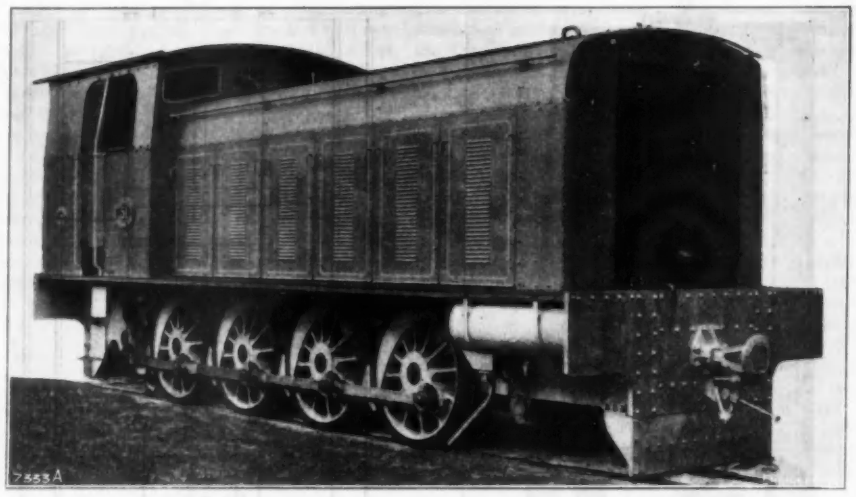


FIG. 1. GENERAL VIEW OF LOCOMOTIVE.

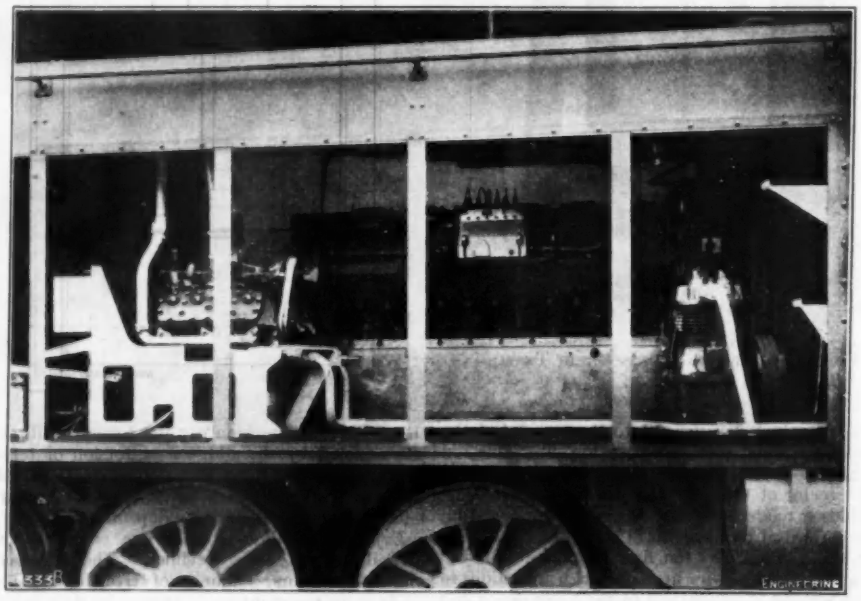
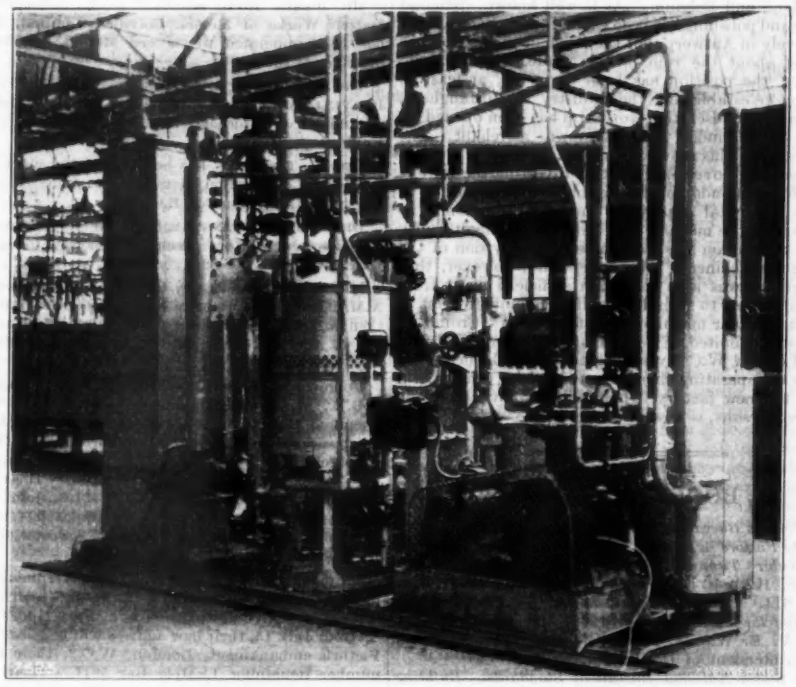


FIG. 2. MAIN ENGINE AND AUXILIARIES.

GAS-CONDITIONING PLANT.

MESSRS. THE INCANDESCENT HEAT COMPANY, LIMITED, BIRMINGHAM.



gear are duplicated on each side of the cab, from which there is a clear view in either direction. The whole of the gear-change operations are carried out by means of the single handwheel referred to above. The gearbox is of fabricated plate construction and is split on each shaft line so that inspection and dismantling are facilitated. The drive from the engine to the jackshaft is, naturally, through a right-angle turn and spiral bevel wheels are employed at this point. All the spur-gears are also of helical tooth form and ball bearings and roller bearings are employed throughout the gear-box. Nickel steel and nickel-chrome steels are largely used in the transmission gear. All the axle boxes and hornblocks are of cast steel, and bronze face liners are fitted to the former. The wheel centres are of cast steel. Westinghouse straight air brakes operating blocks on all wheels through compensating gear are fitted. The air is supplied from a cylindrical reservoir charged at a pressure of 100 lb. per square inch by the two-cylinder air compressor seen to the right of Fig. 2. This compressor was supplied by Messrs. Broom and Wade, Limited, High Wycombe, and is driven from the engine by Thrapston-Vulco endless Vee belts. This reservoir also supplies, through a reducing valve, the air to the transmission control cylinders, whistle, sanding gear, and so forth.

GAS-CONDITIONING PLANT FOR PAINT AND VARNISH MANUFACTURE.

THE formation of a skin on paint and varnish due to atmospheric oxidation is a phenomenon so commonplace as usually to escape comment, and is, moreover, of no great importance where small quantities are concerned. It is, however, a troublesome matter in the manufacture of paint and varnish, but has been successfully combated in the United States by the provision of an inert artificial atmosphere under which the materials are produced and stored. The process has now been introduced into this country by Messrs. The Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, and a short account of the principles of its operation and of the plant involved is given below, a typical gas-conditioning installation being shown in the accompanying illustration. It will be realised in the first place that the production of a non-oxidising atmosphere is not, in itself, a new departure, the novelty in this case arising from its application to a different industry from that with which it is commonly associated, viz., the bright-annealing of ferrous and non-ferrous materials. It will be recalled that Messrs. The Incandescent Heat Company has specialised for some considerable time in this particular field, gas-conditioning units for bright annealing being manufactured by the firm with outputs up to 10,000 cub. ft. of conditioned gas per hour. The base of this artificial atmosphere is usually standard town gas, the volume of conditioned gas being from three times to four times that of the base gas.

It may perhaps be useful to compare the reasons for using protective atmospheres in bright annealing and in paint and varnish manufacture. In the former the atmosphere in the furnace and cooling chambers, with the special sealing devices employed to prevent the escape of the gas and the inward leakage of the atmospheric oxygen, enables heat treatment to be carried out not only without detriment to the surface finish, but with actual improvement. This results in the elimination of the costly secondary cleaning operations which would otherwise be necessary. In paint and varnish manufacture, on the other hand, the atmosphere has somewhat different functions. The mixing and agitation of synthetic varnishes can be carried out more effectively under it and the colour control is more definite. The gas supplied to the varnish kettles is inert and heat can be applied without initiating oxidation. Protection against outbreaks of fire is secured both in the kettles and in the storage tanks, and in the latter case no oxidation or skinning arising from long periods of storage can occur. The pipes can be blown out by the gas and so kept clean. The operating costs, including maintenance, depreciation and all other items, are stated to be very low compared with the savings effected. Thus, as a substitute for CO_2 used as a protective atmosphere, the new gas manufactured from standard town gas costs approximately 6*d*. per 1,000 cub. ft., as compared with 20*s*. to 25*s*. per 1,000 cub. ft. for CO_2 supplied in either the liquid or solid forms.

The gas produced by the generating unit may be adjusted to have a wide range of different compositions, a typical analysis being as follows: Nitrogen 88 per cent., carbon dioxide 10 per cent., carbon monoxide 1·9 per cent., and water vapour 0·1 per cent. There are only traces of the oxides of nitrogen and there is neither oxygen nor sulphur. It will be noticed that the only combustible element, viz., carbon monoxide, is present in such small quantity that the gas has no appreciable fuel value; actually it will not burn, neither will it support combustion of the protected material. It is, moreover, of a strictly neutral inert character, so that neither paint nor varnish are affected in any way. The water vapour content can be kept down to 0·1 per cent. by the use of the silica-gel plant incorporated in the generating unit, and the temperature of the cooling water for the primary condensers, which temperature may vary considerably from summer to winter, has a practically negligible effect. The gas leaving the plant is cold, but rapidly acquires the temperature of the boiling kettle or storage tanks. The plant shown in the illustration will supply approximately 1,250 cub. ft. of conditioned gas per hour at a pressure of 35 lb. per square inch, the base gas supply, town gas, being about 250 cub. ft. per hour. Three motors are required, viz., one of 1½ h.p. for driving the gas and air mixing plant, one of 4 h.p. for driving the compressor, and one of ¾ h.p. for driving the fan.

Briefly, the operation of the plant is as follows:—The base gas is fed into the system and the supply is controlled by a Selas electrically-driven quality-governing mixer which maintains the correct proportion of gas to air precisely. The mixture is then burned in a refractory-lined chamber and passes from this chamber for primary and secondary de-hydration. Primary de-hydration is effected in an apparatus of the ordinary surface-condenser type, the secondary operation being carried out in apparatus employing the regenerative silica-gel system. Any sulphur remaining is removed in the de-sulphurising unit. From the chamber of this unit the conditioned gas then passes into a compressor whence it is delivered to the resin kettles, storage tanks, or to other points in the manufacturing plant requiring a protective atmosphere. The silica-gel unit comprises two adsorbers containing the necessary charge of silica gel, an activation fan, and connecting pipework and valves. One of the absorbers dries the gas while the contents of the other are being re-activated by the passage of hot air through them, the heat of combustion of the original mixture being thus utilised, a condition conducing to efficiency of the plant. The silica-gel charges remain in operating condition indefinitely.

The equipment is completely automatic. The amount of base gas supplied is co-ordinated with the demand for inert gas at the point at which the former is drawn from the supply pipe. The compressor, which delivers the conditioned gas as required, is provided with an automatic device which causes it to idle when the demand for conditioned gas ceases and to start up again when that demand recurs. Governors are provided to maintain the pressure in the storage tank at a constant value and to control the compressor to suit. An important and interesting detail of the plant is an instrument known as the "Analygraph." This is so arranged that a continuous sample of gas as manufactured is taken and any variations in the gas composition are recorded on a chart. The arrangement of the plant, as will be clear from the illustration, is compact and self-contained.

VERTICAL DOUBLE-ACTING TWO-STAGE AIR COMPRESSORS.

THE compact and robust air compressor illustrated in Figs. 1 to 3, on page 30, is an example of a recently designed series constructed by Messrs. Worthington-Simpson, Limited, Newark-on-Trent, in response to a demand for a water-cooled machine which can be run at speeds up to 1,000 r.p.m. and is suitable for delivery pressures up to 150 lb. per square inch. It will be evident from the sectional views, Figs. 1 and 2, that the compressor is of the vertical duplex two-stage crank-operated type, and from the external view, Fig. 3, that it lends itself well to direct coupling to an electric motor. It may be equally well coupled directly to a high-speed internal-combustion engine, or, alternatively, may be arranged for a Vee-belt or flat-belt drive. The compressor, which is known as the "Type D.A. 36," is manufactured in several sizes, of which the machine actually illustrated in Figs. 1 and 2 is intermediate between the largest and smallest. It has cylinders with an upper first-stage bore of 8¾ in., and a lower second-stage bore of 6⅝ in., with a stroke of 5½ in. At a speed of 960 r.p.m., the piston displacement is 366 cub. ft. per minute. Extended continuous running tests at this speed showed an actual delivery of 325 cub. ft. of free air per minute at a pressure of 100 lb. per square inch. The net power required is 73 brake horse-power. The tests were made in accordance with the regulations laid down by the British Compressed Air Society, of which the firm is a member. The next larger machine of the series has an actual delivery of 550 cub. ft. of free air per minute, while the next smaller, a single-cylinder machine, delivers 165 cub. ft. of free air per minute, both performances being made under the conditions already mentioned. A low-pressure series, "Type D.A.S.," is also made, the maximum displacement range of which is from 100 cub. ft. to 900 cub. ft. per minute, at pressures up to 50 lb. per square inch.

Referring to Figs. 1 and 2, it will be seen that the cylinder block is a one-piece casting bolted to a deep bedplate fitted with three main bearings, access to which is obtained through doors on the crankcase extension of the cylinder block. The first-stage valves are housed in the one-piece casting forming the cylinder head and the second-stage valves are carried in the cylinder block. The first-stage delivery, seen at the top right-hand of Fig. 1, is through the gilled tubes of

an intercooler. The intercooler is contained in a detachable cover, clearly visible at the right-hand of both Fig. 1 and Fig. 3. Following the delivery from the first stage in Fig. 1, it will be realised that the air passes downwards through the intercooler tubes into a chamber at the bottom of the cover. This chamber is provided with a condensate drain cock and from it the air is led upwards through a passage at one side of the cover, not visible in any of the views, to the detachable horizontal chamber seen at the top right-hand of Fig. 2, and identified by the pressure gauges visible in Fig. 3. This chamber covers the inlets to the second-stage suction valve of both cylinders, as will be clear from Fig. 2. The suction inlet for the first stage is formed in the cylinder head, as shown at the top right hand of Fig. 2. In Fig. 3, this inlet is shown fitted with a silencing filter. The second stage discharge is seen on the left of Fig. 2, and the arrangement of the second-stage valves is worthy of note in this view as it reduces the second-stage cylinder clearance to a minimum.

The water-jacket spaces throughout are large and effectively disposed. The water is introduced in the central compartment of the intercooler cover and flows directly over the gills of the intercooler tubes, as may be gathered from Fig. 1, into the cylinder and second-stage valve-chamber jackets; thence, by ports of which one is seen in Fig. 2, to the cylinder head, from which it is finally discharged. All the water spaces are accessible for examination and cleaning, and can be completely drained. The incoming air is well insulated by the water jackets from the heated compressed air and all the valves operate in the coolest possible conditions, this arrangement resulting in the maintenance of a high degree of efficiency and, by eliminating carbonisation, ensuring long valve life. The valves are of the flat multi-port type, of a diameter designed to give a low lift. It will be clear that the valve seats are in all cases held down by ported sleeves, in turn held down by bolted examination and removal covers. The suction valves are fitted with the standard Worthington-Simpson regulators, in which system they are held open by air-loaded pistons when the receiver pressure has reached the pre-determined limit. With the suction valves open, the air passes into and out of the cylinders without compression, the compressor still continuing to run.

While this type of control is quite satisfactory with a fluctuating receiver demand, when that demand is intermittent for long periods arrangements for automatic electric start-and-stop control or for constant-speed control are recommended. With the former control, the compressor is automatically stopped when the receiver reaches the pre-determined point and restarted on a fall of pressure. Where the demand for air is continuous, the constant-speed control is desirable. This operates through a relay valve adjusted for a definite pressure range. The compressor unloads when the air demand decreases and reloads when that demand increases, the machine running continuously until shut down by hand. Relay valves are seen on the intercooler cover in Fig. 3.

Pressure lubrication is provided to the main bearings, crankpins and gudgeons by a gear-wheel type pump driven by spur gearing from the crankshaft, as seen at the right-hand main bearing in Fig. 1. The oil pressure is automatically regulated by the spring-loaded valve visible at the left-hand of Fig. 2, and is indicated by a gauge grouped with the air-pressure gauges, as shown in Fig. 3. The pump draws from the bedplate sump through an oil strainer. The oil level is ascertained by a dip stick. The pump spindle is prolonged to the right to carry a driving coupling for a mechanical sight-feed lubricator supplying oil to the cylinders. The course of this supply can be traced at the right of Fig. 1. The rate of oil feed is adjustable, both a regulator and a flushing plunger being fitted. A combined crankcase breather valve and sump filler is fitted to one of the crankcase access doors, and is clearly shown on the right of Fig. 2.

The details of construction of the compressor do not call for particular comment as they follow the makers' general practice, but it may be noted that the cylinder casting is of a hard close-grained cast iron and the bores are carefully honed after machining. The piston is of a special alloy and is finished to close limits. The gudgeon pin is of hardened and ground steel, and is fitted with a bronze bush in the forged-steel connecting rod. The big-end is of the marine type with steel bushes lined with white metal, the main bearings being similarly fitted. The crankshaft is a solid steel forging machined all over, the main bearing and crankpins being finished by grinding. Balance weights are bolted to all the crank webs. The end crankcase cover at the flywheel end is provided with an oil seal for the crankshaft. The flywheel is of cast iron of a heavy disc type. It is shown in Fig. 1 as prepared for the attachment of a flexible coupling on the power unit shaft. Different designs which are available permit the necessary arrangements for belt driving to be made.

DIAMOND-CUTTING FACTORY IN BIRMINGHAM.

A NEW industry, which is likely to be of considerable value to the country's balance of trade, is now being established in Birmingham as a result of the invasion of Holland and Belgium. As is well known, diamond cutting and polishing has been carried on for years almost exclusively in Antwerp, but the German occupation has brought about the ruin of this trade. Fortunately, however, the position has been corrected, at least in part, by re-establishing the industry in Birmingham, where a diamond-cutting workshop has been opened by Mr. J. G. Grinder, a well-known merchant. The importance of this move is two fold. Firstly, it gives us a new source of overseas credit by diverting the world's trade in diamonds to this country, and secondly, it assures the vital supply of industrial diamonds so necessary to the machine-tool industry. One difficulty in this connection was, of course, the provision of the necessary machinery. We understand, however, that Mr. Grinder was able to obtain sufficient plant from the Continent to enable English manufacturers to construct similar machines, and that Messrs. Crompton Parkinson, Limited, Electra House, Victoria-embankment, London, W.C.2, were able to supply the necessary motors for operating them in a very short time. As a result, the new factory, which will employ about one hundred persons, is now in production.

BOOKS RECEIVED.

United States Bureau of Mines. Technical Paper No. 608. *Safety Factors in Construction and Ventilation, Wawona Vehicular Tunnel, Yosemite National Park, Calif.* By S. H. ASH. [Price 20 cents.] Technical Paper No. 614. *Coke-Oven Accidents in the United States During the Calendar Year* 1938. By W. W. ADAMS and V. E. WRENN. [Price 5 cents.] Washington: Superintendent of Documents.

United States National Bureau of Standards. Building Materials and Structures. Report B.M.S. 40. *Structural Properties of a Wall Construction of "Knap Concrete Wall Units," Sponsored by Knap America Inc.* By H. L. WHITTEMORE, A. H. STANG and C. C. FISHBURN. [Price 10 cents.] Report B.M.S. 42. *Structural Properties of Wood-Frame Wall and Partition Constructions with "Celotex" Insulating Boards, Sponsored by The Celotex Corporation.* By H. L. WHITTEMORE and A. H. STANG. [Price 10 cents.] Washington: Superintendent of Documents.

The Early Days of the Power Station Industry. By R. H. PARSONS. London: Cambridge University Press. [Price 15*s.* net.]

United States National Bureau of Standards. Miscellaneous Publication M. 165. *Standardization of Packages.* Washington: Superintendent of Documents. [Price 10 cents.]

Thorpe's Dictionary of Applied Chemistry. By PROFESSOR J. F. THORPE and M. A. WHITELEY. Fourth edition, revised and enlarged. Volume IV. *Digallic Acid to Feeding Stuffs.* London: Longmans, Green and Company, Ltd. [Price 70*s.* net.]

Institute of Metals. Metallurgical Abstracts. (General and Non-Ferrous). Second series. Volume 6. 1939. Edited by S. C. GUILLAN. London: Offices of the Institute.

Philips Practical Welding Course. London: Philips Industrial (Philips Lamps Limited), Century House, Shaftesbury-avenue, W.C.2. [Price 3*s.* 6*d.*]

Home Office. Rubber Trade Conference. Final Report of the Committee on the Guarding of Calenders and Extruders. London: H.M. Stationery Office. [Price 6*d.* net.]

Aircraft Blueprint Reading. By H. V. ALMEN and R. K. MEAD. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

Calculation of Fault Currents in Electrical Networks. Circuit-Breaker Selection. By R. T. LYTHALL. London: Sir Isaac Pitman and Sons, Ltd. [Price 8*s.* 6*d.* net.]

United States Bureau of Mines. Bulletin No. 419. *Metal-Mining Practice.* By C. F. JACKSON and J. H. HEDGES. Washington: Superintendent of Documents. [Price 60 cents.]

The Birmingham Exchange. Directory of Members, Subscribers and Representatives, 1940. Birmingham: The Birmingham Exchange. [Price 2*s.* 6*d.*]

Statement of Accounts, with Annual Reports and Other Statistics, of the Wellington Harbour Board, for the Period Ended 30th September, 1939. Wellington: Wellington Harbour Board.

Year Book and Guide of the Rhodesias and Nyasaland, with Biographies. 1939-40 edition. P.O. Box 1082, Salisbury, Southern Rhodesia: Rhodesian Publications, Limited. [Price 4*s.* 6*d.*]

Trabajos Presentados al Primer Congreso Sudamericano de Ingenieria, Realizado en Santiago de Chile en Enero de 1939. By PROFESOR ING. J. B. BORGARELLI. Montevideo, Uruguay: Profesor Ing. J. B. Borgarelli.

PERSONAL.

MR. H. HATTON, A.M.I.Mech.E., chief designer of Messrs. Brush Coachwork, Limited, Loughborough, has been appointed acting general manager of the Company.

MR. JAMES ROSS, assistant works manager of the Dalzell Works of Messrs. Colvilles, Limited, Glasgow, has been appointed to succeed MR. D. G. FRASER as manager of the works.

The Secretary for Mines has appointed MR. J. ARTHUR REAVELL, M.I.Chem.E., M.I.Mech.E., a member of the Committee on Alternative Fuels for Internal-Combustion Engines.

MR. W. THOMPSON has been appointed chief engineer to Messrs. Magnesium Metal Corporation, Limited, 95, Gresham-street, London, E.C.2.

DR. H. J. T. ELLINGHAM has been elected President of the Electrodepositors' Technical Society for a further year of office.

MR. W. A. BARNETT, M.I.Mech.E., M.Inst.Gas E., A.M.I.Chem.E., formerly engineer to the Barnet Gas Company, Herts, has been appointed engineer and manager to the Mid-Kent Gas Light and Coke Company, Snodland.

Following the release of MR. J. DAVIDSON PRATT, O.B.E., M.A., general manager of the Association of Chemical Manufacturers, 166, Piccadilly, London, W.1, for special service as Deputy Director-General of Chemical Research and Development, Ministry of Supply, the Association has appointed MR. R. MURDIN DRAKE, M.Sc., and MR. ALLAN J. HOLDEN, B.Sc., F.I.C., joint assistant secretaries and managers. Mr. Drake has also been appointed acting secretary of the Association of Tar Distillers.

To make room for an expanding Government Department, MESSRS. CROMPTON PARKINSON, LIMITED, have consented to give up their offices at Bush House, London. As from July 15, their new address will be Electra House, Victoria-embankment, London, W.C.2, their telephone number remaining TEMple Bar 5911. Their associate company, MESSRS. THE ATLAS SPRINKLER COMPANY, LIMITED, are also transferring from Bush House to Electra House, and their telephone number will continue to be TEMple Bar 1146/7. Messrs. Crompton Parkinson's telegraphic address becomes Crompark Estrand (instead of Bush) London, and that of another associate company, MESSRS. THE BRITISH ELECTRIC TRANSFORMER COMPANY, LIMITED, is Transfundo, Estrand, London. That of Messrs. Atlas Sprinkler will remain as hitherto.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electric Trolley-Omnibus Chassis. With reference to the call for tenders for 10 double-deck, 60-passenger trolley-omnibus chassis, noted on page 9, *ante*, we now learn that the closing date has been extended from July 30 until September 24, by the Pretoria City Council. (T. 20,658/40.)

Printing Machines, comprising two letterpress printing machines, paper size 30 in. by 40 in. and 22·5 in. by 35 in., respectively; a book-rounding and backing machine; a grinding and polishing lathe for gravure cylinders; and a four-hole multiple book-drilling machine. Union Tender and Supplies Board, Pretoria; August 8. (T. 20,773/40.)

Electrical Apparatus, including fans (ceiling, desk and wall), kettles, radiators and reflectors. Union Tender and Supplies Board, Pretoria; August 1. (T. 20,778/40.)

Electric Passenger Lift. With reference to the call for tenders for a fully-automatic electric passenger lift for the G.P.O. Building, Pretoria, noted on page 602 of our issue of June 21, we are now informed that the Union Tender and Supplies Board, Pretoria, has extended the closing date from July 25 until August 8. (T. 20,406/40.)

Refrigerating Plants, two, of the air-cooled condenser type, having capacities of 4,000 and 3,500 B.Th.U. per hour, for two cold rooms in Pretoria Mental Hospital. Union Tender and Supplies Board, Pretoria; August 8. (T. 20,774/40.)

Low-Tension Switches, air-insulated, one bank of six, for operation on a 380/220-volt, three-phase, four-wire, 50-cycle system. Union Tender and Supplies Board, Pretoria; August 8. (T. 20,775/40.)

Motor Ambulances, two. General Stores Department, City of Durban, South Africa; August 16. (T. 20,787/40.)

Steam Boilers, including automatic stokers, for Krugersdorp Mental Hospital. Union Tender and Supplies Board, Pretoria; August 8. (T. 20,776/40.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Every effort is being made by industrialists to increase production. The market in raw and semi-finished materials is particularly active; scrap supplies are good, and no complaints are heard from consumers. A similar position exists with regard to pig iron and hematites. The demand for steel bars and billets is substantially greater than at the beginning of the year, and steel sheets and strip are active media. Structural-steel makers are exceptionally busy. Rolling mills, forges, and press shops are well supplied with orders, and a similar position exists in the heavy-machinery and engineering branches, where plants are operating without a break. There is a good demand for reconditioned and second-hand machinery and tools. Stocks at local works have been greatly reduced during the past few months. There is a brisk market for machinery for turning out tools and small machine parts, and cement and concrete mixers find a ready sale. Orders are more numerous in the medium branches. Business in agricultural machinery and parts is brisk, and producers find little difficulty in obtaining sufficient supplies of high-grade steels. Pump makers are busy, large pumps being in demand by municipal enterprises both in this country and abroad. The farm and garden-tool section is busy, and those departments specialising in the production of tools for the engineering trades are producing record outputs. Among the lines in demand are hacksaws and blades, twist drills, milling cutters, reamers, precision tools, machine tools, and lathe parts.

South Yorkshire Coal Trade.—The inland demand is of record proportions and outputs at most pits show an increase over the past month. There is a strong demand for industrial coal, and smalls and slacks find ready markets; steam coal is also in keen request. The call for house coal has been maintained, consumption being well above the seasonal standard. The demand for coke shows a further increase.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Negotiations were in progress last week whereby South Wales coal exports to Portugal will be considerably increased. It was reported on the steam-coal market that in order to maintain the supplies of pitwood, local collieries would have to depend to a greater extent than formerly upon Portuguese wood. Steps were therefore being taken to put back into operation the scheme which has operated between the two countries for some years for the exchange of pitwood for coal. In recent years, South Wales has been importing about 250,000 tons of Portuguese wood annually. At the time the original agreement was reached, Portugal claimed that she used British coals almost exclusively. Since that time, however, local shipments have steadily declined, but Portugal has been showing much more interest in the local market recently and it is confidently expected that exporters will be able to regain most of the trade lost. It has been estimated that, in the present circumstances, South Wales can absorb all the Portuguese timber available, and Portugal should provide an outlet for about 1,000,000 tons of Welsh coal annually. A steady demand was circulating on the market from the South American countries, while deliveries to Eire and home users were proceeding along brisk lines. Rather more business was available for Spain than has been the case for some time. Supplies of all descriptions were usually readily available for early delivery, but the market as a whole presented a very steady tone and outputs at the collieries were being well maintained at recent levels. The forward outlook, however, is rather obscure. All large coals were freely available for prompt shipment, and some of the sized descriptions remained well placed with outlets; smalls were plentiful. Cokes again attracted a keen interest, but supplies were scarce and a strong tone ruled.

The Iron and Steel Trade.—Active conditions continued to rule in the iron and steel and allied trades of South Wales and Monmouthshire during the week. There was still a good volume of business offering and works generally remained busily engaged in fulfilling the orders already on their books.

SWANSEA TIN-PLATE MARKET.—In spite of recent happenings on the Continent, the Swansea tin-plate market continues active and a steady tone is maintained.

THE BENNIE RAILPLANE SYSTEM.—It is announced in *The Railway Gazette* that the structure erected at Milngavie to demonstrate the Bennie railplane system of transport is to be demolished and will yield about 100 tons of scrap.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The general position in the Scottish steel trade has varied little over the week and the high output figures have been maintained. Shipbuilding is accounting for a very large tonnage of the present output and deliveries to munitions factories are on an unprecedented scale. The makers of black and galvanised-steel sheets have a great amount of work on hand and plant is mostly running at full capacity. Owing to the increased cost of manufacture, it has been found necessary to make an advance in prices and the Minister of Supply has made the Control of Iron and Steel (No. 10) Order, varying the Control (No. 8) Order, dated April 4, by substituting a fresh schedule of maximum prices. These advances are not surprising as it was generally recognised that an advance in the prices of iron and steel products was overdue. The following are now the current quotations:—Boiler plates are increased by 32*s.* 0*d.* per ton, from 13*l.* 8*s.* 0*d.* to 15*l.* per ton, ship plates by the same amount to 14*l.* 3*s.* per ton, sections by 25*s.* to 13*l.* 13*s.* per ton. Medium plates (rolled in sheet mills), ½ in. and thicker, are now 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, are now 19*l.* 7*s.* 6*d.* per ton, galvanised plain steel sheets, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and galvanised corrugated sheets, No. 24 gauge, 22*l.* 12*s.* 6*d.*

Malleable-Iron Trade.—In the West of Scotland, malleable-iron trade there has been little change since the last report and makers are all well employed. The advance in prices under the Ministry of Supply Control (No. 10) Order was welcomed by makers because of the heavy extra charges which have lately had to be met. The demand for steel bars is still steady and the re-rollers are being kept fully occupied as the supply of semies is, on the whole, very satisfactory. The new prices are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton, making an advance of 20*s.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; and re-rolled steel bars (tested), 15*l.* 11*s.* 6*d.* per ton, untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Conditions in the Scottish pig-iron industry have not changed, and with the furnaces now in commission, a substantial tonnage is being produced. Makers have satisfactory supplies of raw material at the moment, but as costs have been advancing recently, all prices have been increased by the new Order (No. 10) of the Ministry of Supply.

TRADING WITH THE ENEMY ORDER.—The Board of Trade informs us that it has made a new Order which contains upwards of 350 additions to the "Black List" of traders in neutral countries with whom it is unlawful to have dealings of any kind. Some 130 of these have been specified as a result of Italy's entry into the war, and further additions will be made in the near future. The total number of enemy firms now specified is nearly 1,500. The Order is being published under the title Trading with the Enemy (Specified Persons) (Amendment) (No. 7) Order, 1940 (S.R. & O., 1940, No. 971), and is obtainable from H.M. Stationery Office, price 3*d.* It came into force on June 26.

WORK FOR THE WOUNDED.—Major the Hon. J. J. Astor, Admiral of the Fleet Sir Henry F. Oliver, General W. P. Braithwaite, and Air Vice-Marshal C. A. H. Longcroft are the signatories to an appeal to employers on behalf of the National Association for Employment of Regular Sailors, Soldiers and Airmen, 14, Howick-place, London, S.W.1. The appeal points out that soon there will be men whose disabilities will prevent further active service and that many of them will be capable of, and anxious for, work to help the national effort. The possibility is foreseen that the transference of able-bodied men to more arduous work may create opportunities for employing discharged men, and employers are requested to consider how this might be applied in their own works and offices.

SECTIONAL EXPORT GROUPS IN THE ELECTRICAL INDUSTRY.—Additional sectional export groups under the Electrical Machinery Export Committee, whose secretary is Mr. A. G. Seaman, 36, Kingsway, London, W.C.2, have been formed to deal with electric furnaces, mercury-arc rectifiers, motor starting and control gear and water turbines. Additional groups have also been formed under the Electrical Goods and Apparatus Export Committee, whose secretary is Mr. F. A. Rogers, 36, Kingsway, London, W.C.2, to deal with small switch and fuse gear, portable electric tools, commercial electrical instruments and instrument transformers. As previously announced, membership of these sectional groups is open to all *bona-fide* manufacturers in Great Britain, of the products enumerated, who export or intend to export their products.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Recent advances in the recognised market values of iron and steel have attracted little attention and have not affected the pressure for supplies. The present conditions still confine transactions to narrow limits, and producers are concentrating on the maintenance of deliveries at a rate that covers the actual current needs.

Cleveland Iron Trade.—North of England foundry-iron consumers continue to receive regular and adequate supplies, mostly from the Midlands. Occasional moderate parcels of Scotch iron are obtainable, but the available tonnage of Cleveland pig has shrunk to very small dimensions and there seems little prospect of an early material increase in supply. The make of local iron has ceased, and a resumption of the intermittent production is unlikely. The fixed prices of Cleveland pig are ruled by No. 3 quality at 120*s.*, delivered within the Tees-side zone.

Hematite.—Producers of East Coast hematite have small stocks and the little iron they have on hand is allocated for early use. The exceptionally heavy demand absorbs the large make as soon as it can be distributed, and buyers with extensive running contracts are calling for increased deliveries. After the requirements of the local steelworks have been satisfied, little iron is left for other users. Although makers are managing to meet the actual requirements of consumers, they realise that any great expansion in demand will strain their resources, but they are preparing to deal with the situation when it arises. The stabilised quotations are at the level of No. 3 grade of hematite at 131*s.*, delivered to North of England areas.

Basic Iron.—None of the heavy output of basic iron is available for sale, the makers' own consuming works continuing to absorb the whole of the production. The quotation of 113*s.* is therefore nominal.

Foreign Ore.—The stocks of foreign-ore consumers are much larger than are usually held, and imports continue to arrive regularly.

Blast-Furnace Coke.—As sellers of Durham blast-furnace coke have well-filled order books and local users are very extensively covered, negotiations are few and small.

Manufactured Iron and Steel.—The steadily increasing make of semi-finished iron and steel and other imports of American products are providing re-rollers with ample supplies. In the finished industries, manufactured-iron firms are more actively employed than recently, and steel producers have still to keep their plant operating at full capacity to meet urgent delivery demands.

Scrap.—Iron scrap is in fairly good supply, but there is still some shortage of steel, though deliveries are on an appreciably improved scale.

UNITED STATES TIN-PLATE INDUSTRY.—The production of tin-plate in the United States totalled 2,287,000 tons in 1939, compared with 1,429,000 tons in 1938 and 2,422,000 tons in 1937.

LEAD AND LEAD PRODUCTS.—We are informed by the British Non-Ferrous Controller at Rugby that licences are being granted freely for pig lead for the manufacture of white lead, red lead, sheet and pipe, etc., but that supplies of copper and zinc (spelter) are severely restricted, except for the manufacture of products for service and export requirements. There are ample supplies of lead, and manufactured lead goods of all descriptions are available for prompt delivery. Merchants' stocks of lead products can be sold without licence and all lead goods are available from the manufacturers. Wherever possible information should be given with the order as to the use to which the materials are to be put, thus assisting the manufacturers to maintain adequate labour and obtain licences for their raw materials, packages, etc.

MAINTENANCE AND REPAIR OF MOTOR VEHICLES.—The Ministry of Transport informs us that limited supplies of steel for the repair and maintenance of motor vehicles may be obtained from the purchaser's normal stock-holding merchants. No symbol will be needed under the scheme for the distribution of steel supplies, but it will be necessary to declare that the steel is wanted for "home civil requirements—maintenance of vehicles." In cases in which the demands cannot be supplied by a stock-holding merchant from his stocks, operators and repairers should write to the Regional Transport Commissioner, for the region in which the work is to be carried out, for the necessary forms of application to obtain supplies. Accessories and components, being finished goods, may be purchased from the manufacturers or through the usual channels without a symbol.

VERTICAL DOUBLE-ACTING AIR COMPRESSOR.

MESSRS. WORTHINGTON-SIMPSON, LIMITED, NEWARK-ON-TRENT.

(*For Description see page* 27.)

Fig.1.

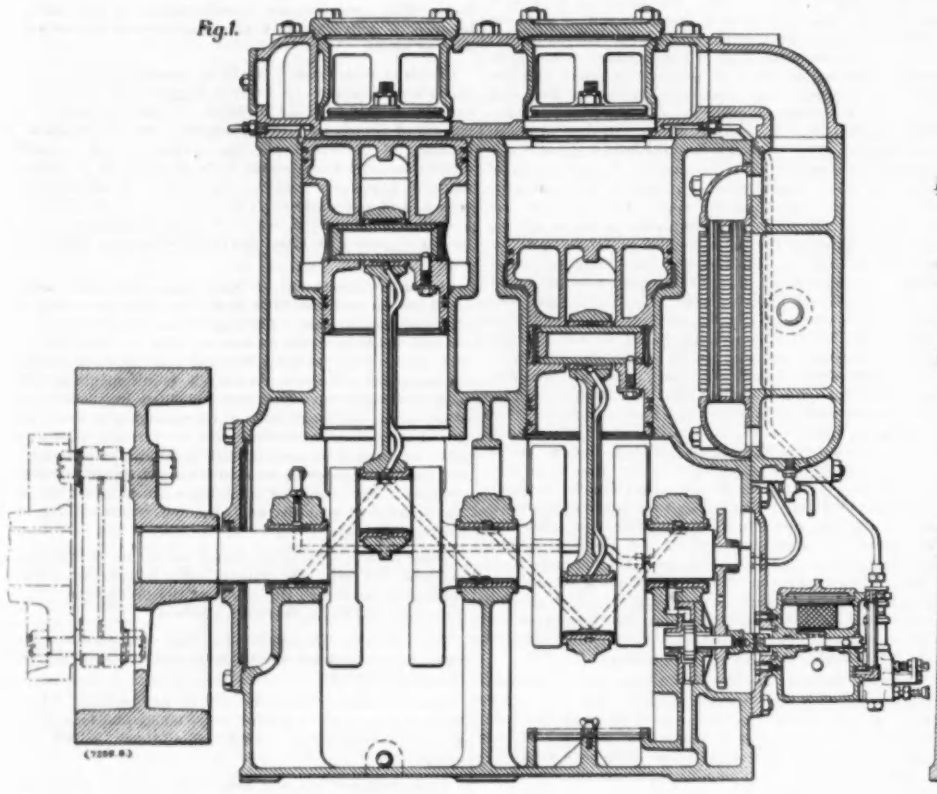
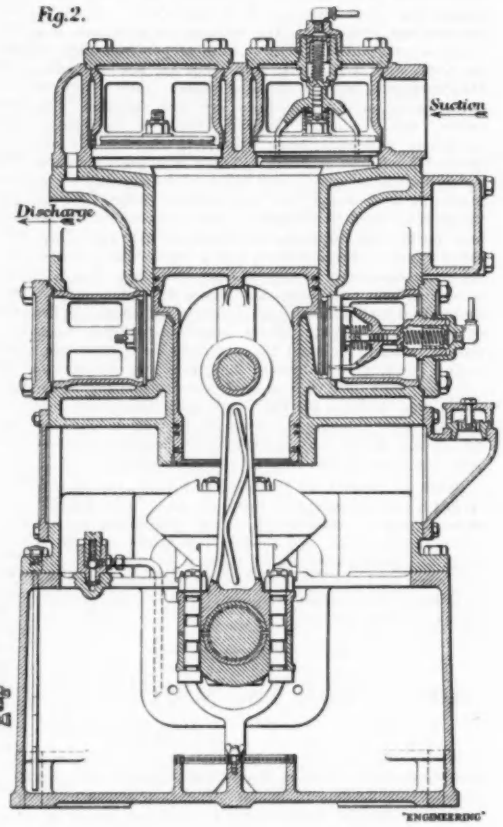


Fig.2.



THE GUARDING OF RUBBER CALENDERS.

THE problems of the effective fencing of calenders and extruding machines in indiarubber factories, though of great importance, have not proved particularly easy to solve. The "*Rubber Trade Conference Final Report of the Committee on the Guarding of Calenders and Extruders*,"* has, however, just been published, and the recommendations contained therein satisfactorily fill the gaps which had been left from the Interim Report of January, 1938. These related to three classes of calender-bowl nip, viz.: (1) Feed nips of all types of vertical and other calenders of three or more bowls; (2) nips, other than feed nips of the special purpose calenders of three or more bowls, referred to in the Interim Report; and (3) nips of two-bowl calenders. The feed nip is defined as the nip at which the rubber stock, as prepared for the calender, is first fed into the machine. The fact that feed nips are ordinarily out of the way of inadvertent contact and are blocked to some extent by the rubber stock, caused consideration of their fencing to be set aside for more pressing points in the Interim Report, but the Committee are now satisfied that it is possible to safeguard feed nips in various ways, which are set out in the Final Report.

The second part of the Report deals at length with those calenders of three or more bowls which differ in their arrangement from the standard vertical calender. The danger in such machines is that the operator's hands may be in close proximity to a nip when his attention is distracted by the necessity of attending to the feed nip, and the risk is particularly great in such machines as small offset shoe calenders. Methods of safeguarding machines of the classes outlined above are described and illustrated by means of typical examples, but it is held that the most complete solution of a number of outstanding problems can only be arrived at by the co-operation of the designers of calenders, so that fully effective types of guard may be fitted and greater convenience in use secured by attention to the general lay-out of the machines; for example, the height and relative position of the several bowls and appliances. The final part of the Report discusses the safeguarding of two-bowl calenders used for various rubber-sheeting purposes. Illustrated suggestions of guards which have been found serviceable are given. The location of calender motor-starter gear, the precautions necessary when cleaning calender bowls, and clothing for calender operators, are discussed.

* H.M. Stationery Office. [Price 6*d*. net.]

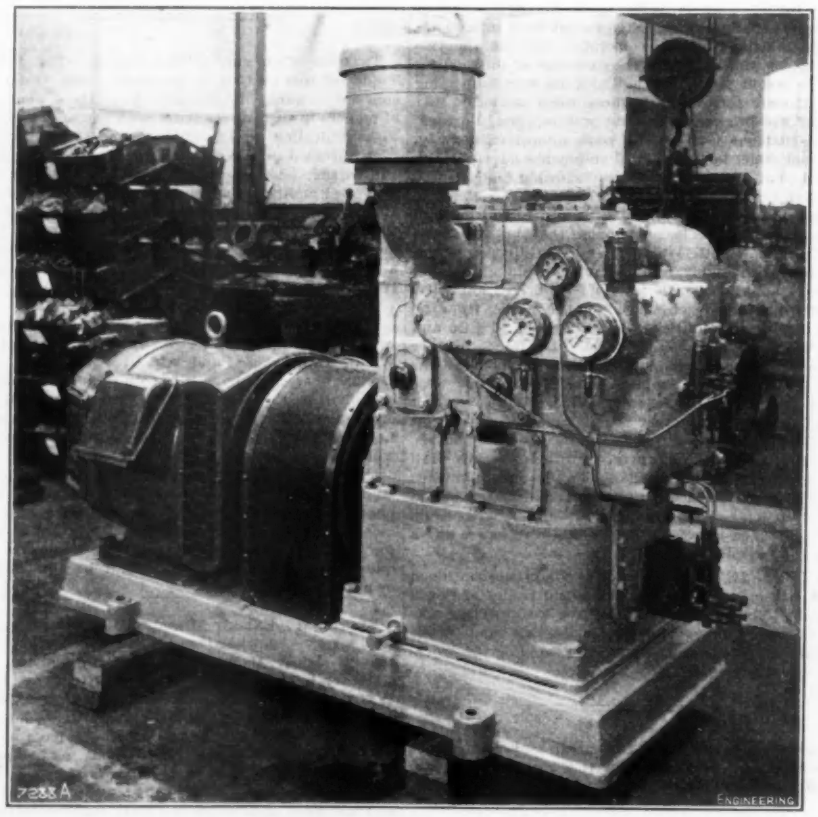


FIG. 3. MOTOR-DRIVEN TWO-CYLINDER COMPRESSOR.

JUNCTION RAILWAY CONNECTING THE [N]OR[TH]

(For Description see page 21.)

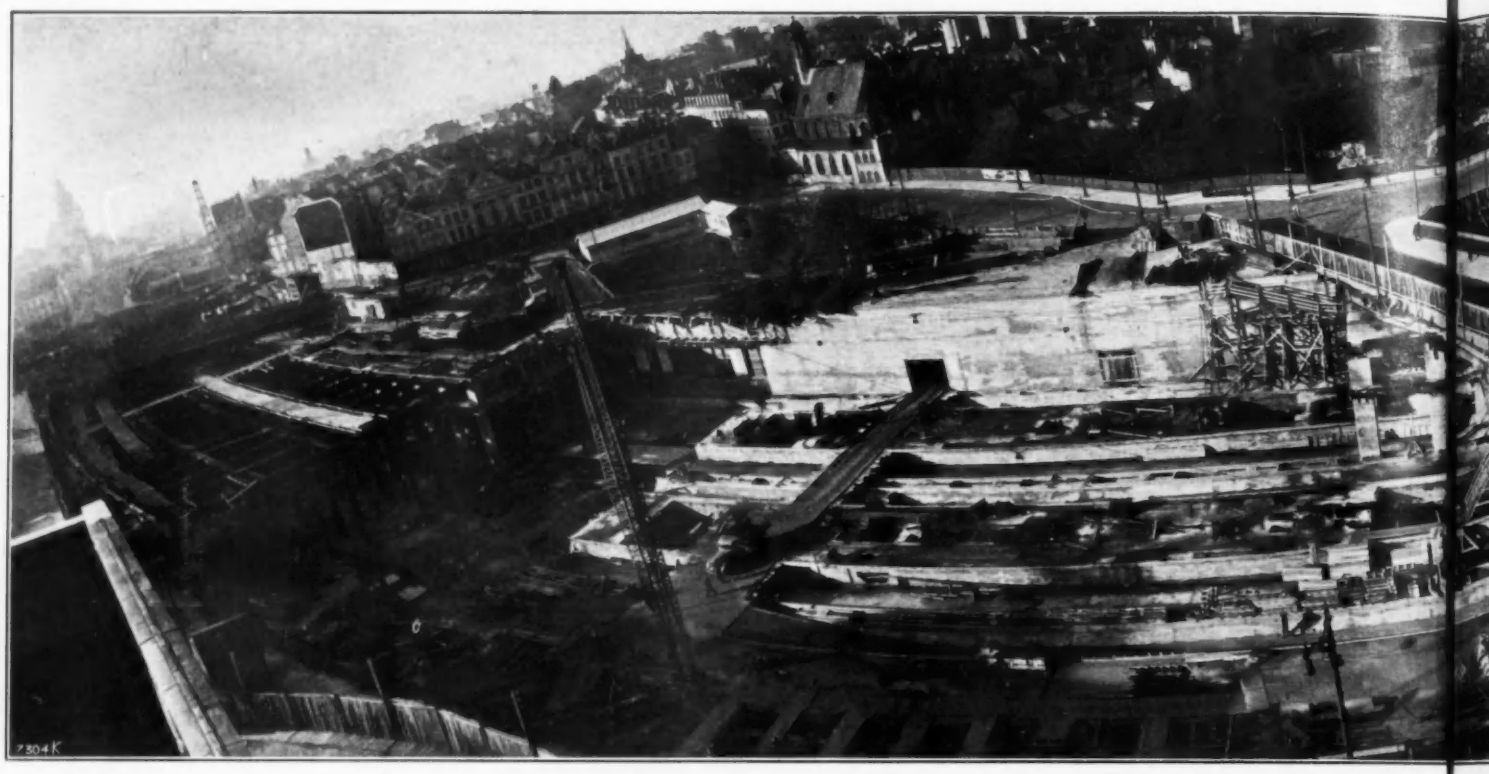


FIG. 12. AERIAL VIEW OF CENTR[AL] STA[TION]

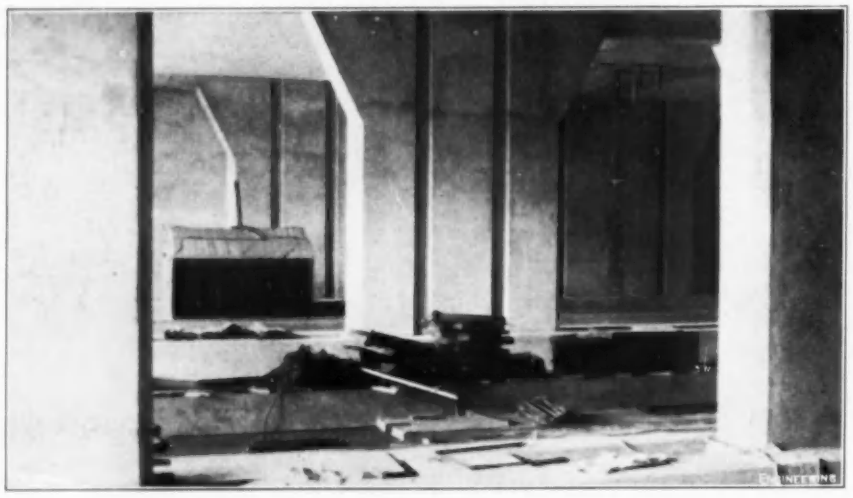


FIG. 13. INTERIOR OF TUNNEL NEARING COMPLETION.

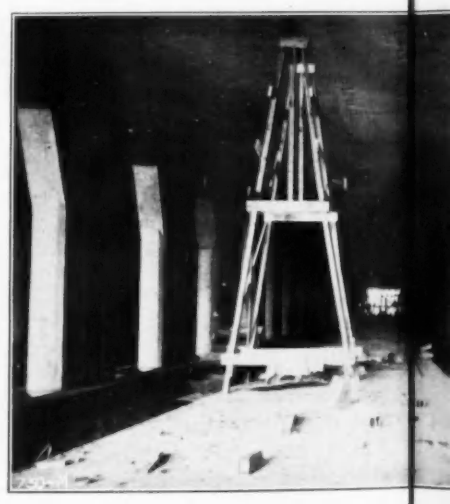


FIG. 14. PLATFORM AT CHAP[EL] HA[RDY]

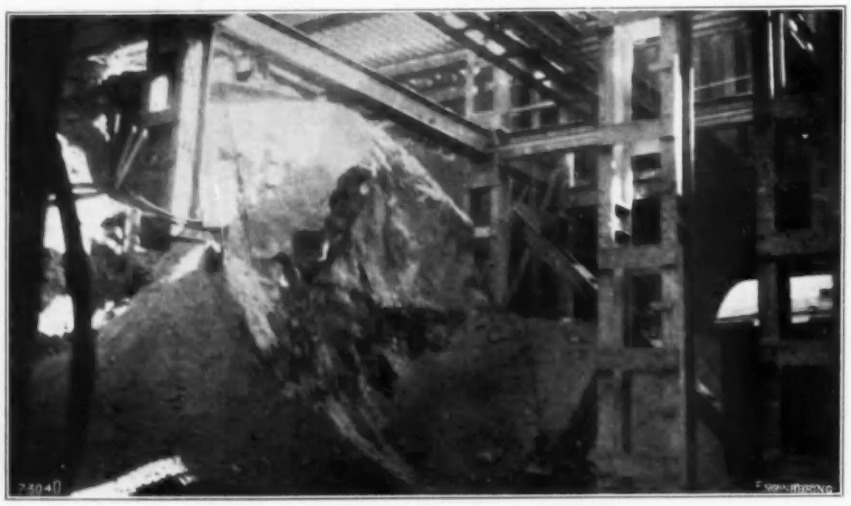
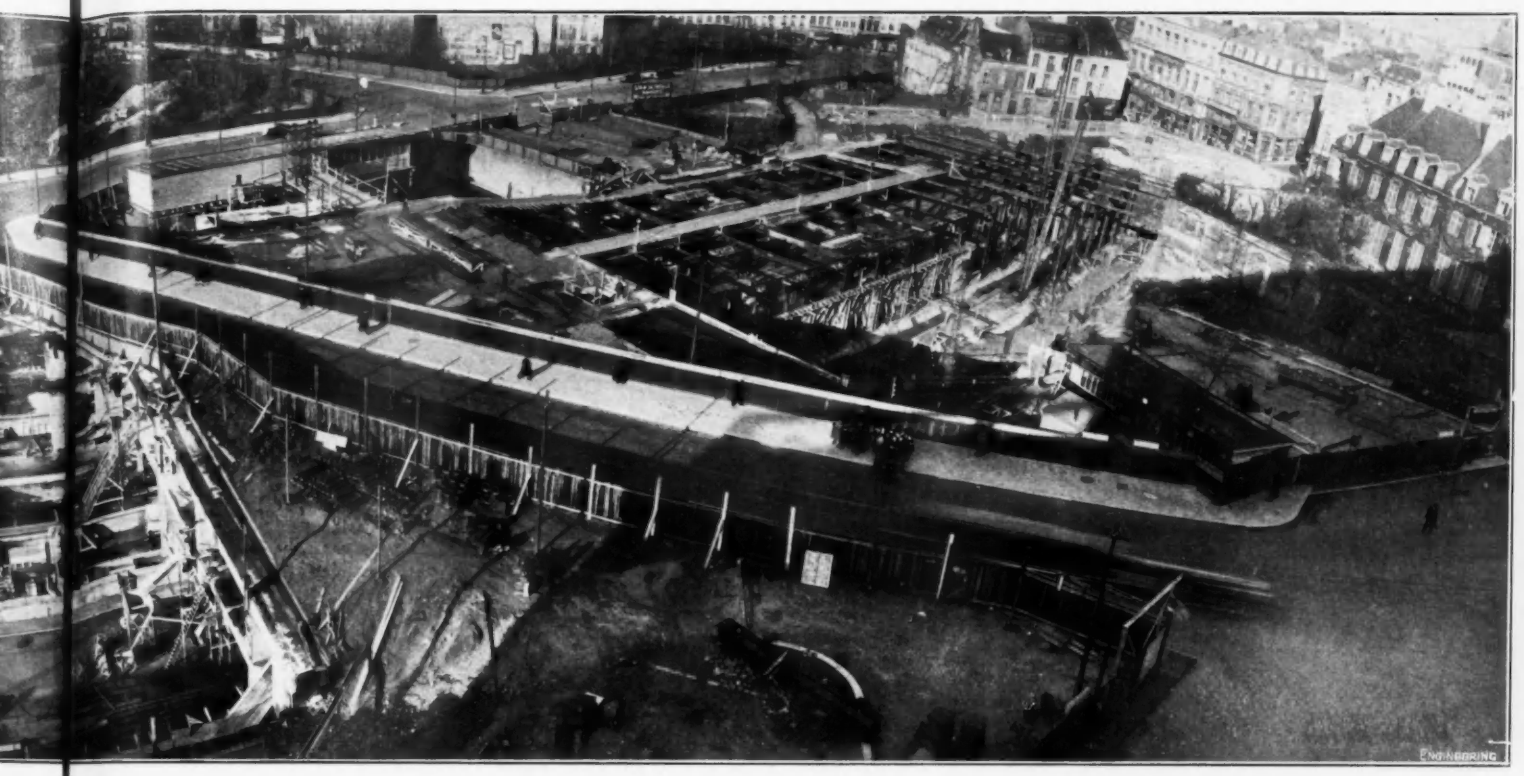


FIG. 16. EXCAVATION DURING TUNNEL CONSTRUCTION.

FIG. 17. LOADING SPOIL FOR TRANS[PORT]

HE ORTH AND SOUTH STATIONS, BRUSSELS.

(For description see page 21.)



F CENTRAL STATION DURING CONSTRUCTION.

F CHAPELLE HALT UNDER CONSTRUCTION.

IL FOR TRANSPORT TO SOUTH STATION.

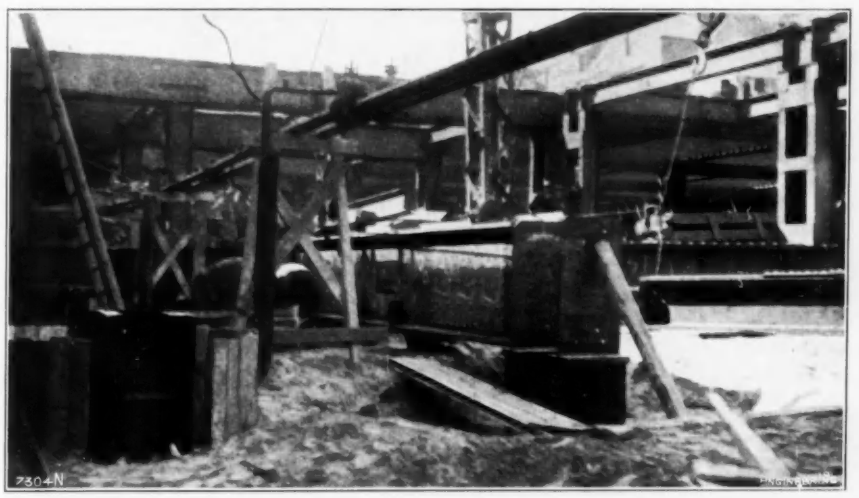


FIG. 15. UPPER STEELWORK OF TUNNEL DURING ERECTION.

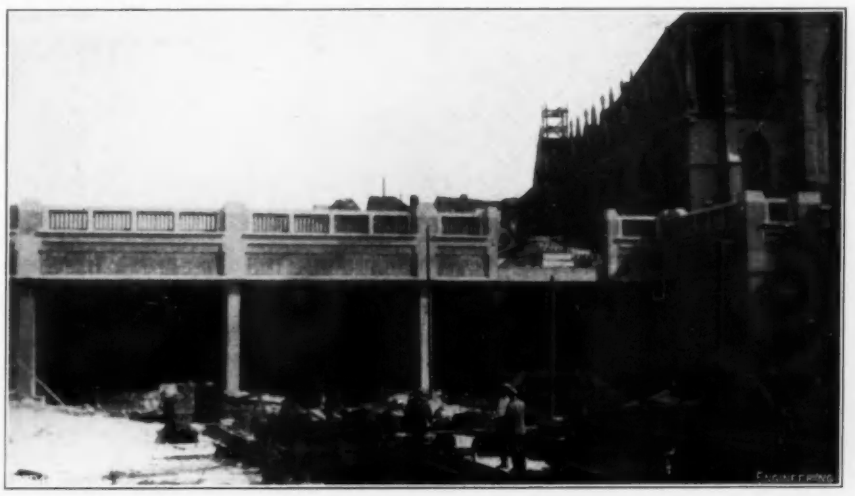


FIG. 18. SOUTH PORTAL OF TUNNEL.

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, JULY 12, 1940.

VOL. 150. No. 3887.

WASTEFUL SALVAGE.

"IT is the business of the wise in this world to correct the mistakes of the good." The quotation is from a sermon delivered more than 30 years ago in circumstances which need not be particularised; the author is still alive, and probably would be considerably astonished to think that his casual epigram of a time that now seems very remote should be recalled by any incident arising from a major war. But it epitomises rather neatly the situation that is being created all over the country by many well-meaning citizens whose knowledge and judgment are inadequate to withstand the onslaught of a skilfully-worded slogan. Typical of this class are those to whom was addressed a recent letter in *The Times*, appealing to them not to present to scrap-collecting organisations such *objets d'art* as articles of old Sheffield plate, with the intention that they should be melted down for the sake of the metal. The nation has need of metals at this juncture, but not yet so dire a need that it must sacrifice, solely for the sake of the material, irreplaceable examples of a skill in arts and crafts that can only flourish in that state of civilisation that the war is being fought to preserve.

It is always a pity to damp well-intentioned enthusiasm, but the fervour with which the campaign for scrap collection is being pressed, especially now that compulsion is being applied to local authorities to co-operate in it, does introduce a real danger that objects of considerable historical, æsthetic and, perhaps, commercial value, may be "liquidated" in a way that provides for the common cause only a negligible fraction of the assistance that might be forthcoming if their disposal were directed more knowledgeably. To take an extreme and wholly hypothetical example: a scrap of paper bearing a genuine signature of, say, Shakespeare or Sir Thomas More, would present an infinitesimal contribution if treated only as so much paper, but would purchase a very useful amount of equipment if converted into cash in a sale room.

The same principle, of making the best use of ostensible scrap instead of merely the most obvious use, is applicable throughout the whole range of discarded industrial products which the public is now being urged to collect and contribute to the national effort. Warnings have been issued already against the indiscriminate destruction of railings and other ornamental wrought-iron work, and—by the Master of the Rolls—against the pulping of valuable parochial and other legal records and documents. That this danger is not being overlooked in official circles is further shown by a circular recently issued by the Ministry of Health to local authorites throughout the country, defining more exactly the classes of documents which should be preserved for historical reasons, for purposes of audit, or "because they may be wanted (perhaps in the remote future) in connection with judicial or quasi-judical proceedings affecting the status or rights of private persons."

The concluding paragraph of this circular touches upon an aspect of waste collection which applies even more forcibly to metals than to paper. Observing that the papers likely to be discarded by local authorities will probably contain a useful proportion that is of high grade, it recommends that, where any substantial quantity is available, the waste should be sold either to authorised merchants or to mills which have facilities for sorting and classifying it in the best interests of the industry. Some similar warning appears to be very desirable in the case of scrap-metal collecting, especially the gathering by municipal dustcarts of all the miscellaneous "junk" that has accumulated in the homes of the nation. The greater part of the occupants of those homes are not skilled in the classification of metals; capable, to some extent, of identifying lead, and of distinguishing tin from aluminium, but regarding most other non-ferrous metals in common use as "brass," and anything that is ferrous as "iron." The average scrap merchant carries the sorting process a stage further, recognising cast and wrought metals, and possibly being able to differentiate between iron and steel in many cases; but it is too much to expect him to identify the many special alloys, ferrous and non-ferrous, that have been developed in recent years for special purposes, most of which are not distinguishable by any obvious peculiarity, but only by laboratory tests carried out by skilled personnel.

In the production of the higher-quality alloys, however, it is essential that the nature of the constituents should be known with some accuracy. The inclusion in a melt of the old smooth-bore muzzle-loading cannon, lately contributed to the scrap campaign from the Tower of London, would probably affect the final product no more than would an equal quantity of cast iron from discarded oil-engine flywheels; but the use as scrap of steel gun-barrels from the last war might have a decidedly deleterious effect on the suitability of the resulting melt of steel for particular purposes. Such experiences were, in fact, encountered some years ago, by a Midlands firm of steel makers, who traced an unexpected difficulty in welding their steel to the inclusion in the scrap content of a quantity of gun parts.

While the presence of unwanted alloying constituents may represent technical impurities, there is a considerably more extensive class of impurity, likely to be encountered in a nation-wide collection of old material, which may restrict the utility of the reclaimed metal. The difficulty of dissociating the zinc when remelting galvanised steel is well known; although it may be remarked, in passing, that this does not seem to have affected the sale, for breaking-up purposes, of small naval vessels, such as destroyers, the plates and frames of which are commonly galvanised, to prevent corrosion during building. It may be recalled, however, that a paper read last November before the Society of Naval Architects and Marine Engineers in New York established a connection between the observed cold-shortness of rivets in United States destroyers and the fact that the rivets were connecting galvanised plates. Where the plates were spot-faced round the holes before riveting, to remove the galvanised coating, the failures of rivets dropped to negligible proportions.

Enamel coatings from old advertising signs,

motor-vehicle panels, etc., may be presumed to be completely removed in the slag on remelting, and it is possible that an appreciable addition to available scrap resources might be obtained by a drastic weeding-out of the signs which disfigure so many miles of English road sides. The posts supporting Belisha beacons have been reprieved on the solicitation of the Ministry of Transport, but a great deal might be done to combine on one post adjacent signs which are now separately mounted. Here, however, the cost factor enters prominently into the case, and a critical examination of the circumstances might well show that an inordinately high price would be paid for such scrap as would be rendered available by action of this kind if carried out by local authorities. At the same time, the opportunity to remove many of the unsightly signs and to profit by their removal is too good to be ignored, and there is no doubt that an appeal to the public to assist by taking down such signs as have no further utility, and to deliver them to the nearest collecting centre would meet with widespread approval and practical support.

The question of cost has always impeded the tidying process that must be maintained in any modern community if the accumulation of rubbish is to be kept within reasonable bounds. Among less developed peoples, the whole problem of scrap utilisation takes on a different aspect, and in many cases—for example, in the Middle East, in India and in China, the people themselves may be trusted to see that no possible opportunity is missed of turning usable material to account. Where suitable labour can be obtained, as in India, for a few shillings a month, there is enough inducement to managers of works and factories to rescue and recondition much material that, in any western country, would not be worth salvage. Much more might be done in present circumstances, however, to recover usable material if the problem of cost were examined anew and a little trouble taken to organise the collection and grading of miscellaneous scrap with that object.

Although the results are less immediately obvious, it is probable that more benefit might ultimately accrue to the national resources by thus conserving old material and so reducing the demand for new, than by gathering it indiscriminately, transporting it about the country, sorting it into the very approximate categories which alone are generally practicable, and finding in the end, that the bulk of the material is still so heterogeneous in composition that it can only be used for making products such as hand-grenade cases, which are intended to be broken and which, once used, are virtually lost. Undoubtedly, the appeal of Major H. E. Crawfurd, on page 35 of this issue, to plant engineers and others, to reduce the quantity of odd material held in reserve for possible emergencies, will produce a valuable accession of metals of all kinds, but it is very necessary that a proper discrimination should be exercised to ensure that too high a price is not ultimately paid for material which may have to be replaced, at considerably increased cost, while the war is still in progress.

This is not to suggest, of course, that the appeal is ill-conceived, for there can be no question that many plant engineers are given to hoarding all manner of old material on the general principle that it "may be useful some day." Judging by ordinary observation, however, it would appear that much still remains to be done in merely collecting the odd scraps of plate, fragments of broken castings, short lengths of discarded piping, and stray bolts and rivets which are not being hoarded at all, but are allowed to lie where they have been dropped. The difficulty, in many cases, is to arrange for the collection of such small consignments as may be gathered in this way; three or four hundredweight of old iron is too much for the ordinary dust-cart to accept on its rounds, but is not enough to justify a scrap merchant sending a lorry specially to collect it. A possible solution would be to arrange a definite collection at a given time from, say, all the motor repairers in a town; on another day, to collect from builders' yards, and so on. The problem of the salvage of scrap appears at first sight easy, especially to the public; but in fact it is one of the most complex to solve economically of all those that war conditions have forced into prominence.

THE CUNARD CENTENARY.

In less troubled times, public and Press alike would have collaborated with general satisfaction to celebrate such an event as the centenary of the Cunard Line, and of the departure for America of the company's first steamer, the Britannia, on July 4, 1840. Under war conditions, however, merely commemorative functions obviously are out of keeping, even if those who would have the task of organising them were not so fully occupied with duties of national importance. Nevertheless, the occasion is one which should not pass entirely unrecorded, for the history of the Cunard Company is very closely bound up with the development of British steam shipping, more particularly on the North Atlantic.

The events leading to the formation of the company, and its subsequent history down to the amalgamation with the White Star Line, were surveyed at some length in ENGINEERING of May 15, 1936, in connection with the completion of the Queen Mary, but may be briefly recapitulated. Sir Samuel Cunard's interest was rekindled in the possibility of a regular transatlantic steam service—a project that he had previously considered without taking any action upon it—by the British Admiralty's call for tenders for the conveyance of American mails by steamship. Through Robert Napier, the Clydeside shipbuilder, he was introduced to George Burns and his partner, David MacIver, who submitted a successful tender, and together they contracted with the Admiralty for the construction of the four paddle steamers Britannia, Acadia, Columbia and Caledonia. The Britannia, which inaugurated the service, was built by Robert Duncan, of Port Glasgow, and was engined by Robert Napier. The original title of the undertaking was the British and North American Royal Mail Steam Packet Company, but eventually the more convenient name of the "Cunard Line," by which it was popularly known, was adopted officially.

For ten years the company encountered no organised competition, but in 1850 severe inroads on its monopoly were made by the Collins Line, but the Collins shareholders withdrew their remaining ships in 1858, after losing the Arctic in collision in 1854 and the Pacific, which disappeared with all hands, in 1856. Other competitors followed, however, and for many years the Cunard Line had to face a vigorous rivalry from the Guion, Inman, Hamburg-Amerika, Norddeutscher-Lloyd, Compagnie Générale Transatlantique, and White Star fleets. A succession of notable ships, however, secured the position of the Cunard Company, the Umbria and Etruria, in 1884-5, being followed by the Campania and Lucania in 1893 and the Lusitania and Mauretania in 1907. The Atlantic record, held by the last-named vessel, was wrested from her by the German liner Bremen in 1929, and subsequently changed hands at comparatively frequent intervals, but the completion of the Queen Mary in 1936 once more placed the company definitely in the forefront of the Atlantic express-liner traffic, and there is no doubt that the Queen Elizabeth would have established this position still more positively, had the war not intervened to terminate all normal sailing schedules.

It is difficult to overestimate the prestige which the operations of the great British shipping lines have conferred, in the aggregate, upon the world standing of the nation's mercantile marine, or the financial benefits which have resulted, in the form of "invisible exports," to the nation and the Empire as a whole; and it is to be hoped that the value of these services will not be overlooked in high legislative circles when the problems of re-establishing normal conditions are being considered. As Lord Essenden stated in his address as chairman of Royal Mail Lines, Limited, on June 28, the last thing that the shipping industry wishes to do is to profit unduly from war conditions; but it is vitally important that such a national asset as the liner fleets should not be so impoverished as to be unable to resume, with reasonable promptitude, the world transport services which they have built up, almost entirely by private enterprise, and have maintained in the face of prolonged depression and heavily subsidised competition.

NOTES.

AN AIRCRAFT BALANCE SHEET.

Two significantly contrasting sets of figures regarding British and German air power were published at the beginning of the week. Naturally these figures have a wider tolerance than those with which engineers are accustomed to deal, though the desirability of this inaccuracy must be admitted. According to a statement issued by Lord Beaverbrook, Minister of Aircraft Production, the number of aircraft we produced during June was more than double the total produced in the same month of last year, when preparations for war were already in full swing. We had also turned out more than twice the number of engines, thus increasing the reserve. It was added that the American aircraft now arriving represented a considerable contribution to the British air fleet, and the shipments from that country would soon give an additional output in each month which would be of material assistance. The total value of the aircraft orders placed in the United States amounted to well over 1,000,000,000 dols. From Canada, also, over 50,000,000 dols. worth of aircraft and parts had been bought, and deliveries of certain types were coming forward in increasing quantities. On the other side of the balance sheet is the official statement that, since the start of the war, Germany has lost almost 2,500 aircraft against this country alone. This figure does not include the losses caused by the French, Dutch, Belgians and Norwegians, nor those suffered as the result of accidents. There must also have been many casualties from machines so badly damaged as not to be able to reach home. Though these losses have no doubt been made up to some extent, by new construction and, perhaps, by captures, they have been accompanied by corresponding losses in pilots, and these are much less easy to replace in a short time. There remains the question how far Germany's stocks of materials are affecting her manufacturing output, but there is no need to be pessimistic about this. Therefore, the position may be viewed with modified optimism, although the need to maintain and increase the output continues to be insistent.

THE ORGANISATION OF MAN POWER.

An authoritative statement on the organisation of the country's man power, which was issued on Monday evening, though it dealt mainly with the steps that are being taken for the direct defence of the country, also contained some important information regarding the position on what may be called the labour front. One of the most unfortunate things, it is pointed out, from which the country has been suffering is the waste of valuable skill which occurred during the ten years before the war. In these days such skill is of the highest importance, and it is now belatedly accepted that in future greater regard must be paid to the maintenance of the skilled capacity of our workpeople. It is to be hoped this lesson now learnt will not be forgotten, and that its full implications will be realised in the period of reconstruction which must follow the war. As regards the present, the aim must be to utilise such power as we possess as efficiently as possible. In this connection it is satisfactory to learn that the workers have responded in a remarkable way to the necessity of transfer and that practically no compulsion has been necessary. In addition, the Ministry of Labour has decided to ask everyone employed in certain categories to register at once with the labour exchanges, so that, immediately our machine-tool capacity is increased and adjusted, their services can be utilised. A complaint that has been frequently made is that skilled men have been drafted into the fighting Forces and utilised on such duties as mess waiters; so that it is reassuring to learn that more men have been put back into industry from the unemployed by training and by upgrading than have been taken out of industry for the Forces. At the same time, every care should be taken that, both within the Forces and without, every man is employed on the job for which he is best suited. The Ministry hopes, also, to be able to continue to fill every gap in production caused by men being taken for the Forces

and by establishing more training centres to give the munitions industry 100,000 trained men a year. The regulation of wages and arbitration on matters in dispute will be the subject of an early Order, while much is being done on the welfare side and an effort is being made to develop an industrial medical service. This is all to the good. The only criticism is that it ought to have been done before.

Increase in Timber Prices.

The position with regard to the supply of timber was reviewed in these columns last week, when it was pointed out that we were now importing a larger quantity of timber than we had done since the war started and that this amount was fully equal to our essential requirements. Two new orders, which were published last week, show, however, that this satisfactory state of affairs cannot be maintained without some sacrifice. Though the average cost of purchases abroad is little, if at all, above the pre-war price level in the currency of the exporting country, there are several factors which render the final costs in this country very much higher than in peace time. Germany's unrestricted war on merchant shipping—particularly neutral shipping, the necessary institution of the convoy system, and other war conditions have, in fact, together resulted in a considerable rise in freight rates, particularly in the case of a commodity as bulky as timber. The depreciation in the pound sterling and the heavy cost of war insurance are other items which necessarily go to swell import costs. Consequently a drastic alteration in selling prices has become necessary, now that the time has arrived for the stocks of nationally-owned timber to be generally released. New increased prices, as we announced last week, have, therefore, been fixed for imported timber. These new prices will apply to the remainder of the private stocks held by merchants and others, but in order to prevent additional profits accruing to such stockholders a charge will be imposed on the sales and use of such stock, and this will be based on the difference between the new prices and the maximum prices ruling before July 1. In future, too, transactions netween merchants will be subject to licence, and the maximum limits for consumption by consumers from their own stocks without licence will be reduced. Further, all acquisitions of timber are now subject to licence except in the case of timber acquired up to a value of 1*l.* once a month. The licensing system is extended to all transactions in both imported and home-grown timber, and the 2*l.* limit of exemption from price control is reduced to 1*l.*

The Certification of Electricity Supply Meters.

The Electricity Supply (Meters) Act of 1936 provides rather elaborate machinery for the testing and certification of the meters used by authorised undertakings for the supply of electricity. At a meeting with the Electricity Commissioners on Friday, June 21, representatives of the Joint (Emergency) Committee of Electricity Supply Associations urged that, with a view to releasing skilled men for war work, this machinery should be modified by suspending the requirements regarding certification for the duration of the war. The suggestion that both the clerical work connected with certification and the tests themselves should be simplified with a view to effecting additional reductions in the amount of time involved had already been discussed with the Meter Technical Committee and, as a result of a report made by the Chief Meter Examiner, it appears that, if the modified programme now proposed is adopted, the amount of testing involved would be little, if any, in excess of that which the undertakings would have to do if certification were suspended. In these circumstances, it is felt that the number of additional skilled staff which could be released is negligible, especially as it is thought that the complete suspension of meter certification should be avoided. In other words, some meter testing, even under war-time conditions, will be necessary, and even if certification were entirely suspended, the number of skilled staff which could be released would be small. Nevertheless, a number of simplifications have been introduced, which have been embodied in a long circular address to the undertakings, and this has been accompanied by a notification that all unnecessary testing, such as that occasioned by bringing in meters merely because the premises in which they have been installed have been vacated, should be discontinued. It is also pointed out that further economies in testing would be possible if all new meters were tested and certified at the manufacturer's testing stations.

Leverhulme Research Fellowships.

In May, 1933, a scheme of research fellowships was announced, in accordance with a direction in the will of the first Viscount Leverhulme that the income arising from part of his estate should be devoted to the granting of scholarships for "research and education." Various beneficiaries have already been able to take advantage of this munificence and a further list, published this week, shows that the war has not interrupted the activities of the trustees. These latest awards, which are tenable for periods up to two years, include one to Mr. R. M. Davies, lecturer in physics, University College, Aberystwyth, for experimental investigations on turbulent flow in an air tunnel: this is a renewal of the present fellowship. Dr. A. G. Gaydon, Radiation Gas Research Fellow, Imperial College, London, has been granted a fellowship to undertake a spectroscopic study of combustion processes in flames and explosives, and Dr. N. A. V. Piercy, Reader in Aeronautics, University of London, is to investigate the mathematical theory of wing sections. The other researches are of a non-engineering character, but it may be mentioned that Mr. J. R. Bellerby is to deal with post-war economic reconstruction and Mr. W. H. Warburton is to survey the North Staffordshire pottery industry.

Canadian Hospitality for Engineers' Children.

A generous offer has been made to the Institutions of Civil, Mechanical and Electrical Engineers, through the medium of the Engineering Institute of Canada, to arrange for the reception in the homes of Canadian engineers of children of members of the three institutions who have no relatives or personal friends in the Dominion to whom the children might be sent. As a result of the restriction imposed by the Government on further registrations under the official scheme for the evacuation of children overseas, applications can be received at present only from those members who have already registered. Any member who has thus registered, and who wishes to take advantage of the offer of the Engineering Institute of Canada, should inform the secretary of his institution immediately. When he receives the official notice of acceptance, he should again communicate with the secretary of the institution, who will then furnish him with a certificate to ensure that the child in question is included in the scheme. This certificate is intended to be submitted with the acceptance form. In order that a complete record may be kept of the children who are to be received into the homes of Canadian engineers, members are asked to inform the secretaries of their respective institutions as soon as the child leaves home for the port of embarkation. Members who have not yet registered, but who are interested in the scheme, are asked to advise the secretaries of their institutions of the fact, pending the resumption of registration.

Charles Chree Medal and Prize.—The report of a committee appointed to consider the regulations which shall govern the award of the Charles Chree Medal and Prize has been received and adopted by the Council of the Physical Society. The award will be made, without restriction of nationality or of Fellowship of the Physical or any other Society, normally in alternate years beginning with 1941, for distinguished research in terrestrial magnetism, atmospheric electricity and related branches of knowledge in which Dr. Chree was specially interested. Each award is to consist of a silver medal, a parchment certificate, and a sum of money. Government securities to the value of approximately 2,000*l.*—in July, 1939—have been transferred to the Physical Society by the founder, Miss Jessie S. Chree, who afterwards generously added a further 50*l.* to defray a part of the initial cost of the design of the medal and the preparation of the dies.

THE RIVER PLATE MARKETS.

In the article, "The Markets of Latin America," which appeared in Engineering of May 17, it was pointed out that, unlike most of the other Latin American nations, the River Plate countries of Argentina and Uruguay found it possible to escape the necessity of submitting to Germany's pre-war trading penetration through that country's "compensation" system. This was possible because the grain and meat products of the River Plate area normally found a ready sale in Europe, particularly in Britain. Moreover, again unlike most other South American countries, Argentina and Uruguay have been enabled throughout the past years of crisis to maintain a high credit standing through the uninterrupted service of their foreign bonded debt.

From the first arrival of the Spaniards in South America some centuries ago, their main economic motive was the mining of the precious metals, gold and silver, in the mountainous plateaux in Peru, Mexico, etc. Although the farming development of the River Plate basin occurred in comparatively recent years, that area is now commercially the most highly developed and richest of South America, and is one of the chief granaries of the world. This development has been largely due to the efforts of British engineers and financiers, and British capital invested in Argentina is calculated to total some 430,000,000*l.* sterling, and in Uruguay, 39,000,000*l.* sterling. Nature has so disposed matters that, in return for the large cargoes of coal and manufactures supplied by Britain in normal times, this country receives from Argentina essential cargoes of grain, meat, etc., and also wool from Uruguay. The grain and other products shipped from Argentine ports in pre-war years averaged about 14,000,000 tons per annum, of which about 50 per cent. was carried in British ships, which fact in itself assisted towards lower freights for manufactures shipped from Britain. The British-owned railway systems are also largely responsible for the movement of grain shipped to the coast. Special mention must be made of the Argentine meat industry, which is unparalleled in its organisation and service. It is the outcome of ideal pastoral conditions in that country and of the breeding of cattle suitable for English consumption, the present high grade of beef being achieved by the importation of British pedigree cattle, so that Argentine chilled beef is one of the staple foods in a large proportion of British homes. The importance to the world of the enormous shipments of Argentine grain, particularly wheat, maize and linseed, is too well known to need stressing, while Argentina is also one of the greatest wool-producing countries in the world. The cultivation of cotton and other farming products has recently made extraordinary strides.

Table I.—*Argentina: Imports and Exports.*

Year.	Imports (Market Values).	Exports (Market Values).	Trade Balance.
	Pesos.	Pesos.	Pesos.
1913	1,127,788,850	1,179,900,025	+ 52,111,175
1915	694,290,922	1,323,134,725	+ 628,843,803
1920	2,124,926,588	2,372,921,295	+ 247,994,707
1928	1,901,608,474	2,396,608,299	+ 494,999,825
1933	897,148,929	1,120,841,512	+ 223,692,583
1934	1,109,932,444	1,438,433,978	+ 328,501,534
1935	1,174,981,223	1,569,349,057	+ 394,367,834
1936	1,116,710,994	1,655,712,396	+ 539,001,402
1937	1,557,684,380	2,310,997,802	+ 753,313,422
1938	1,460,887,797	1,400,452,807	− 60,434,990
1939	1,338,332,419	1,570,226,299	+ 231,893,880

Even in war time, although the loss of the German and other European markets, through the British blockade, is an increasingly serious matter, the export trade of the River Plate countries has been maintained so far at something like normal levels through the continued large purchases by Britain of meat, wheat, etc. Under the relative reciprocal Trade Agreements with this country, this guarantees a continued exchange preference for British imports in both the Argentine and Uruguayan markets. Although the River Plate countries may be faced with the over-production of farming products while

the present war lasts, they should, nevertheless, be in the vanguard of world recovery once hostilities cease; their economy is sound, and their productive capabilities will eventually be in great demand to restore an exhausted Europe. Meanwhile, from the long-term point of view of the import markets for manufactured goods in the River Plate, it is only to be expected that—as happened during the Great War and the subsequent years of crisis, marked by intense economic nationalism in Europe—the present difficulties of importation will give added stimulus to the already important national manufacturing industries in Argentina and the other South American countries.

The population of Argentina, at December 31, 1939, was 13,129,723 persons, compared with 12,956,602 at December 31, 1938. The population of the federal capital of Buenos Aires at the end of 1939 was 2,364,263 persons, while the most populated provinces were Buenos Aires (3,486,430), Santa Fé (1,540,880), Córdoba (1,271,494) and Entre Rios (737,300). The area of Argentina extends over as much as 1,112,743 square miles, which is equivalent to 29 per cent. of the area of Europe. The coast line is about 1,600 miles, exclusive of the estuary of the River Plate, which serves as the main seaward entrance. The River Plate is less a river than an estuary or great basin into which flow the rivers Paraná and Uruguay, together with their tributaries. The chief natural divisions are the Andine, occupying the eastern slope of the Andes in the North West; the Chaco, or northern lowlands, forested and with a semi-tropical climate; the Pampa, the economic heart of the country, extending fanwise 400 miles from Buenos Aires, devoted to cattle-raising and cereals; and Patagonia, the southern plateau, given over principally to sheep farming. The enormous annual value of Argentina's oversea trade is shown by the comparative figures in Table I, on page 33; for purposes of approximate valuation, the conversion rate into sterling may be taken at 15 pesos per £. This tabulation compares the figures in the year immediately preceding the last Great War, as well as the war-year of 1915, the international depression of 1933, the boom year of 1937, and the two subsequent years. The outstanding feature, it will be observed, is that, apart from the year 1938, when the crops were a failure, Argentina has throughout maintained a very large favourable trade balance. This is the secret of her economic stability, her high credit standing both at home and abroad, the steadiness of the exchange situation, and the corresponding ability to pay for imports.

Although Argentina is so widely identified with the meat trade, the major percentage of the exports of the country is agricultural, as distinct from pastoral. This is shown by the comparison in Table II, herewith, of the principal export items in the years 1939 and 1938:—

TABLE II.—*Principal Exports from Argentina.*

Exports.	Volume in Metric Tons.		Market Value in Pesos.	
	1939.	1938.	1939.	1938.
Wheat ..	4,744,000	1,940,000	274,354,000	183,410,000
Maize ..	3,196,000	2,642,000	202,574,000	180,522,000
Linseed ..	1,183,000	1,265,000	170,211,000	181,223,000
Meat ..	665,000	639,000	330,332,000	317,568,000
Wool ..	149,000	152,000	162,740,000	153,752,000
Hides ..	170,000	158,000	113,930,000	101,259,000

Despite the fact that the lack of iron and coal militates against the development of Argentina's manufacturing industries, and at present 75 per cent. of the manufactured products used are imported, there has been a notable development in the manufacturing industries. The last industrial census, in 1935, showed that there were 40,367 industrial establishments, with an installed motive power of 2,557,376 h.p., employing 534,736 workmen, and turning out goods to the value of 3,442 million pesos. The most important manufacturing industry is textiles, but iron and steel manufacture is expanding in the country, where many articles, from small screws to highly complicated foundry products, are now made. Among many other industries, shipbuilding shows notable activity, and there are numerous manufacturers of such commodities as electrical fittings, paints and varnishes, and chemical products. National cement manufacture has caused imports to fall drastically. There are 1,304 million pesos invested in the electricity industry, with 898 power houses distributing current to about 800 cities and towns, and these figures do not include firms who provide their own electricity. The total electric power produced annually, some 2,000 million kWh, is distributed in the city of Buenos Aires alone to the extent of 1,500 million units, and in the province of Buenos Aires, some 130 million units. The potential hydro-electric power in Argentina is estimated at 5,000,000 h.p., but of this only about 35,000 h.p. has been developed. Most of the larger stations are in the province of Córdoba, on the Rio Primero, and Mendoza, on the Rio Mendoza and the Canal Zanjon. Great distances separate the potential sources of energy—the Iguazu Falls, the rapids of Apipe, and the falls of the Salto Grande—from the consuming centres. Argentina is becoming increasingly rich in petroleum production, the output from the State oilfields in 1939 reaching the record total of 1,625,000 cub. m., while the output for the first four months of 1940, at 597,337 cub. m., was 16 per cent. more than in the corresponding period of 1939. The largest output is still at Comodoro Rivadavia, but there has been remarkable increase in production from the newly opened wells in Mendoza.

Throughout South America, increasing attention is being paid to developing vital means of transport, and there is an expanding demand for aeroplanes and motor vehicles. A traffic census on the highways under the control of the Argentine National Highways Department at the end of 1939 showed that the number of automobile vehicles counted had increased, since a similar check in 1935, by 43 per cent., to a total of 99,325, whereas horse-drawn vehicles had declined by 27 per cent. to 14,534 vehicles. According to figures issued by the same Board, and based upon the petrol tax returns, the total consumption of petrol in Argentina in 1939 was 1,303 million litres, compared with 1,188 million litres in 1938—an increase of nearly 10 per cent. The law passed some time ago for the co-ordination of transport throughout Argentina has not yet been given practical effect, although a similar law relating to Buenos Aires alone has resulted in the formation of the Transport Corporation there, on the lines of the Transport Board in London, and rationalisation of the city's transport problem is now in progress. The difficult situation of the British-owned railways is well known, and the Argentine Government has formed a special committee to report upon the economic situation of the railways, following upon a petition seeking increased tariffs because of the effect of the European War, particularly in regard to the higher cost of fuel. As will be seen from the accompanying Table III, the outstanding feature between the years 1936 and 1938 (the latest year for which details are available) was the increase in imports of vehicles.

Generally speaking, the outlook in Argentina is reasonably good, the economic and financial situation being sound, while the Government took prompt steps to deal with the repercussions of the European War. The main problem at present is the marketing of the large maize crop, and if maize prices continue at their present low level this may adversely affect the purchasing power of the farming community, with a consequent restricted demand for agricultural machinery, tractors, replacements, etc.

The Republic of Uruguay is bounded on the south by the broad estuary of the River Plate and has an area of 72,153 square miles. The climate is one of the healthiest in the world and the greater part of the land is suitable for arable farming. The population was estimated, in March, 1939, at 2,133,000 persons, with by far the greatest density in the department of Montevideo. The country is given up almost entirely to grazing, the breeding of cattle and sheep constituting the principal source of wealth, and wool being the prime export. As in other South American countries, communications by airways are rapidly increasing, while the roads are among the best in South America; steady progress is being made in this direction. The railways, principally in British hands, all converge upon Montevideo. Although there has been a certain amount of industrial development in Uruguay, this has not been important, particularly in engineering lines. In 1937, work was commenced on the damming of the Rio Négro, and the construction of plant capable of producing 500,000,000 kWh per annum. Work was to have been completed about 1941, but as the contract was granted to Germany, it has been interruped by the war, and the present position is obscure.

TABLE III.—IMPORTS OF ENGINEERING PRODUCTS INTO ARGENTINA: TARIFF VALUE IN THOUSANDS OF PESOS

	Great Britain.		U.S.A.		Germany.	
	1936.	1938.	1936.	1938.	1936.	1938.
Iron and Steel, and Manufactures	22,804	16,526	11,477	11,308	24,534	31,326
Other Metals and Manufactures	21,815	18,826	9,742	10,693	9,676	10,029
Machinery and Motors	7,706	8,399	14,272	16,161	8,797	14,690
Agricultural Machinery and Implements ..	175	400	10,405	42,367	1,187	1,665
Vehicles	8,686	32,786	26,830	55,134	4,463	16,274
Electrical Materials	2,438	3,057	9,825	9,793	5,405	5,338
Fuel and Lubricants	56,240	57,219	28,860	33,810	6,114	8,625

TABLE IV.—IMPORTS OF ENGINEERING PRODUCTS INTO URUGUAY: TARIFF VALUE IN THOUSANDS OF PESOS.

	Great Britain.		U.S.A.		Germany.	
	1936.	1938.	1936.	1938.	1936.	1938.
Metals and Manufactures and other Rough Goods	421	567	2,465	2,346	824	1,659
Electrical Materials	23	125	408	319	598	1,258
Automobiles and Spares	601	1,128	1,809	1,546	341	855

In 1938 and 1939, the estimated total market value of imports into Uruguay was 95,570,429 pesos and 84,090,243 pesos, respectively, against exports of 96,342,734 pesos and 101,366,303 pesos; so that, as for many years past, Uruguay maintained a favourable balance of trade. For purposes of valuation, the equivalent exchange rate is about 6 pesos per £ sterling. Illustrating the importance of the pastoral industry, out of the total exports in 1938 of, say, 96,000,000 pesos, livestock products represented 80,000,000 pesos, of which wool accounted for 42,000,000 pesos, meat and extracts 22,000,000 pesos, and hides 11,000,000 pesos. Imports of engineering and allied products into Uruguay in 1936 and 1938 (the latest year for which official figures are available) compare as shown in Table IV, on this page.

The above figures are not very detailed, the first item (Metals and Manufactures, etc.), for example, covering a very wide range, including metals, hardware, naval materials, petrol, oils, paints, glass and pottery, while the third item includes not only automobiles and spares, but also motor vehicles of all kinds, aeroplanes and bicycles. In the latter category, it will be observed that imports from Great Britain expanded considerably between 1936 and 1938. The increase in imports from Germany of metals and manufactures and electrical materials may be ascribed largely to the contract awarded for the Rio Négro hydro-electrification scheme, already mentioned.

Paraguay is not so commercially important as

either Uruguay or Argentina. Steady recovery is being made, however, from the protracted war with Bolivia, a year or so ago, over the Chaco problem. Paraguay is an inland country, with a total area of 161,000 square miles, the chief trade artery being the Paraguay River. The country is almost entirely devoted to agriculture and pasturage, stock-breeding being a staple industry, while timber of the finest quality is available in unlimited quantities. Communications are primitive, but a far greater productive power may be expected as capital is applied for development purposes, and tractors, modern ploughs and agricultural implements in general are being introduced upon a new and large scale. Manufacturing production is unimportant. At present, United States experts are assisting in monetary stabilisation, while financial aid from the same source is forthcoming for the development of the country.

British manufacturers who are not familiar with South American trading conditions, and who may wish to take the opportunity to extend their markets, should now be able to secure assistance from the Export Council, through their appropriate group, particularly in regard to the formalities introduced by the Defence Regulation in this country; but a brief account of the usual methods of doing business with the River Plate countries, as well as a short reference to the regulations in force on the other side, may serve some useful purpose. In the case of the River Plate markets, it should be emphasised that these regulations are not onerous, being intended to permit the authorities to control (without necessarily restricting) the entry of foreign goods, so as to ensure an even flow of exchange with which to pay for them.

Two ways of opening connections present themselves, namely, the appointment of a local agent or a personal visit by a representative who speaks Spanish. The Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, has issued memoranda on methods of trading and the appointment of agents in the various South American countries, in the form of separate booklets which also contain valuable data on customs and consular requirements, shipping documents, marking, storage, advertising, travellers' licences and samples, weights and measures, and many other matters. As regards Argentina, additional sources of information are the British Chamber of Commerce in the Argentine Republic (Inc.), Bartolomé Mitre, 441, Buenos Aires, and the Argentine Chamber of Commerce in Great Britain, Bush House, Aldwych, London, W.C.2. Up-to-date reports and information on marketing conditions, agencies, etc., in most Latin-American countries, are also available at the Bank of London and South America, Limited, 6, Tokenhouse-yard, London, E.C.2, and at the British and Latin American Chamber of Commerce, 11a, Union-court, London, E.C.2.

A commercial visitor to the River Plate should avoid the summer months of January, February and March, if possible, but, generally speaking, there are no fixed buying seasons, except for textiles. No extensive travelling in the countries is entailed, since practically all the import merchants are centred in the capital cities of Buenos Aires (Argentina), Montevideo (Uruguay), and Asunción (Paraguay). The metric system is employed throughout South America and the use of British measures should be avoided, therefore, in quotations and estimates. The unit of currency in Argentina, Uruguay and Paraguay is the *peso*, which is subdivided into 100 parts, called *centavos* in Argentina and Paraguay and *centesimos* in Uruguay. In all three countries the "peso" means a paper peso for all practical purposes, the gold peso being no longer used for quoting prices, rates of exchange, etc., so that calculations are quite simple to make.

The financing of exports to South America is an important point. A large proportion of trade is conducted by means of documentary bills sent through a bank for collection, although Argentine and Uruguayan importers frequently open letters of credit which permit payment to be obtained against documents in London. When bills are sent for collection they are usually drawn on Uruguayan and Paraguayan buyers at sight and occasionally at 60 days, but, in the case of Argentina, although many sight bills are drawn, the usance generally extends up to 90 days. The British Defence Regulations, which require payment for our exports to be received within six months, naturally preclude long credit terms, owing to possible delays to mails.

British trade with both Argentina and Uruguay is based upon existing Trade Agreements, both of which provide for the reciprocal supply of exchange to pay for imports from Britain, according to British purchases from them. Moreover, under war-time conditions, Britain is extending the system of sterling clearing agreements in South America, and a Treasury Order of June 14, 1940, requires all commercial or current financial payments to and from the United Kingdom and Argentina to be made in sterling through an Argentine Special Account with an authorised bank in this country. At the time of writing, a similar arrangement with Uruguay is imminent. So far as concerns the exchange control regulations in the River Plate markets, these may best be summarised under the three countries concerned:

Argentina.—A permit, known as a prior exchange permit, must be obtained before any goods are ordered abroad. This duty falls upon the importer, but the exporter on this side should take the precaution of ascertaining that a permit has been granted. The policy of the Argentine Government is to control importation both as to articles and source on the principle of reciprocal trade, and, while many goods may now be imported without limit, in other cases quotas apply. The permits are normally valid for five months in respect of goods from the United Kingdom, the period being extended to seven months in the case of machinery in general. Imports are divided into two groups: (1) those which are paid for at the official rate of 17 pesos per £, and (2) those which are paid for at the preferential official rate of 15 pesos per £. Changes are made from time to time at the discretion of the authorities, but, generally speaking, the greater part of Argentina's imports falls into the first group, the second group covering articles which cannot be produced in the Republic or which are regarded as essential imports. For example, fuel and lubricants, most metals, iron tubes and bars, brass or copper tubes, iron and steel wire not galvanised, non-electrical domestic cooking and heating apparatus, and printing machinery obtain the preferential rate of 15 pesos, but machinery in general, motors, motor-vehicles, electric motors and dynamos, cables and other electrical material and apparatus, constructional material, and hardware in general are paid for at the rate of 17 pesos.

Uruguay.—An import permit is also required in Uruguay, and, although the regulations do not stipulate a "prior" permit, British exporters are recommended to ask the buyer to obtain a permit before the goods are shipped. This avoids the risk of the goods lying in the Customs House after arrival, pending the issue of a permit. The Uruguayan exchange-control system is different from that ruling in Argentina; each importer is allotted a yearly quota of foreign exchange, and within this total he can obtain import permits as and when exchange becomes available, the supply being regulated by announcing monthly quotas for each supplying country. The controlled rate of exchange for imports is at present 6·07 pesos per £, but if the goods are imported under quotas provided by exchange derived from exports of meat made under current contracts between Uruguay and Great Britain, the fixed rate of 7·63 pesos per £ is used.

Paraguay.—There is no official exchange control in Paraguay and a system of import permits, which was introduced last year, has recently been discontinued. Paraguayan currency is quoted in terms of Argentine currency, the present rate of exchange being about 71 Paraguayan pesos to one Argentine free paper peso.

PANAMA CANAL TRAFFIC.—Vessels to the number of 5,567, having a total net tonnage of 25,239,441, and carrying 28,166,897 tons of cargo, passed through the Panama Canal during the year ending April 30, 1940. The corresponding totals for the previous 12 months were 5,828 ships, aggregating 26,774,455 net tons and carrying 27,322,151 tons of cargo.

LETTERS TO THE EDITOR.

SCRAP IRON AND STEEL.

TO THE EDITOR OF ENGINEERING.

SIR,—Those industries which use iron and steel, or the equipment of which involves the use of machinery, have been approached by the Iron and Steel Control with a view to their making available such supplies of iron and steel scrap as are in their possession. There has been a considerable response to this appeal, and that response has been largely helped by the ready co-operation of the technical Press. There is, however, evidence that there is still a large amount of available iron and steel lying in factory yards and sheds, and in maintenance departments, which might well be surrendered as scrap in the national interest at the present juncture.

It is characteristic of maintenance engineers, and those in charge of repair and maintenance departments of works generally, and who are keen and conscientious, to make it a habit to keep supplies of spares, and indeed, of obsolete parts and machinery, lest, when the need arises, they should be found short. There can be no criticism of this attitude; but, on the other hand, the national need for all available iron and steel, either as discarded machinery and parts, or as scrap, is so great to-day that it outweighs even the advantages of providing against the future, so far as individual firms are concerned.

I am therefore writing to you in order that, through the medium of your paper, I may appeal to heads of firms to see that as much of this kind of material as possible is given up for the purpose of being converted into iron and steel for munitions and armaments. May I suggest to them that even the provision of what may possibly be needed in the future by their own firms should take second place to the urgent national need. We all know that armaments and munitions for the fighting forces are needed in ever-increasing quantities. These cannot be provided in abundance unless a continuous flow of scrap is forthcoming. Therefore, I make this further appeal that everyone should join in this drive, even if it involves personal sacrifice.

Yours faithfully,
H. E. CRAWFURD.

Iron and Steel Control,
427, Bush House, London, W.C.2.
July 4, 1940.

MOBILISING HOME WORKSHOPS.

TO THE EDITOR OF ENGINEERING.

SIR.—There is still an unemployed reserve of useful equipment and mechanical skill in this country. I refer to the home workshops and services of model engineers and amateur mechanics, of which there are a large number capable of producing excellent work. Many of these workshops are well equipped with tools, and, though the owners may be engaged during the day on some form of national service, or may be over military age, they are willing and anxious to devote their spare time to the production of munition details. During the last war, hundreds of thousands of shell bases, and fuse and gauge parts, were machined in home workshops of this kind.

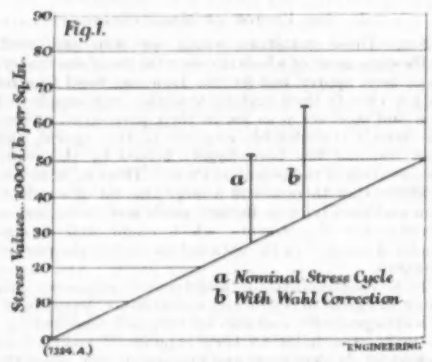
I am now compiling a register of these workshops, and already have over 300 offers of service. The spare-time production of one worker may not be much, but in the aggregate the production may be a valuable contribution to the country's munition needs. If each worker devotes 20 hours a week to the work, the total result of 6,000 production hours is equivalent to the work of 100 full-time mechanics. I know of one small group of retired people in the Home Counties who, by well-planned effort, are producing 1,000 machined pieces a day for a nearby works.

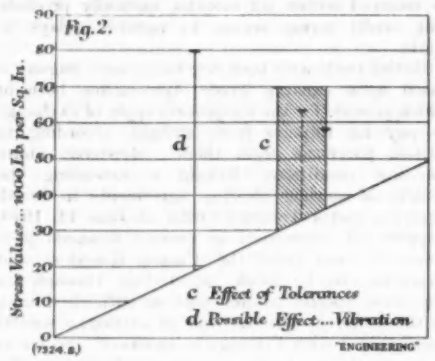
My register is growing daily, and my desire is to find suitable work for these enthusiastic volunteers to do. They are situated in all parts of the country; some of them are capable of doing precision work to micrometer limits, others could do useful roughing-out at lathe or bench. They may not be able to deal with the heavier products or components required, but there are hundreds of jobs to be done, within their capacity, particularly in connection with tool and gauge and jig making, or with the lighter kinds of munitions. Some of these workers are already co-operating with the excellent technical-school scheme organised by the Board of Education, but there are many others who are still looking for something useful to do. If any of your readers are in a position to make use of such additional production service, I shall be happy to furnish them with the names and addresses of likely helpers in their areas.

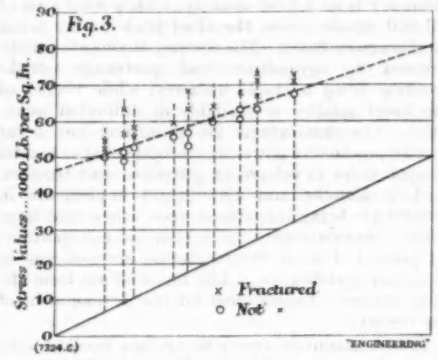
Yours truly,
PERCIVAL MARSHALL.

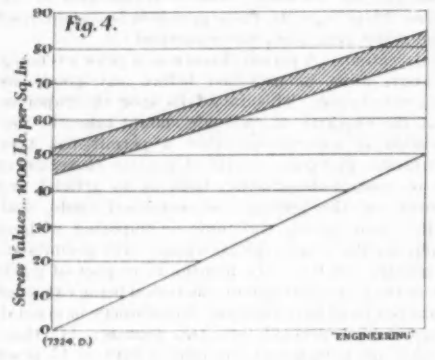
"The Model Engineer,"
60, Kingsway, London, W.C.2.
July 5, 1940.

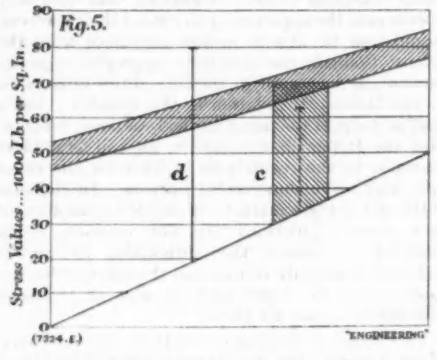
THE FATIGUE OF HELICAL SPRINGS.











FATIGUE OF HELICAL SPRINGS.*

By RODMAN R. TATNALL.

EVEN though fatigue failures are not a problem in many spring uses, occasionally, in the application of helical springs to various types of mechanisms, failures by fracture are encountered, usually after some considerable period of service. Practically all are cases of progressive fracture, since helical springs are just as susceptible to fatigue phenomena as are other machine parts which have been widely studied. Indeed, helical springs may be more susceptible than other parts, because they are so often designed with little or no factor of safety, and the majority of designs make use of as much of the available elasticity as possible. The mechanism of spring fatigue parallels other types of fatigue, and many of the theories developed from the vast amount of study already given the subject apply equally well to springs.

In the following discussion, a typical spring, which has given trouble from fatigue failures, is taken as an example for which the complete analysis of the problem is worked out. This example is a compression spring, made of a pretempered straight carbon steel, to the following specifications:—Outside diameter, 1·0 in.; wire diameter, 0·148 in.; free length, $2\frac{7}{16}$ in.; total coils, $11\frac{1}{2}$; coils closed, $1\frac{1}{2}$ each end; ends ground square. Load: 40 lb. at $2\frac{1}{4}$ in. length, and 76·5 lb. at $1\frac{43}{64}$ in. length. Commercial tolerances apply and a stress-relief treatment is given in the course of manufacture.

Under the topic, amount of work expected of the spring, which is the main factor in spring fatigue, the important feature is the stress cycle imposed on the wire, rather than the technical value of the work done. From the load values specified, fibre stress is readily determined from the standard formula

$$S = \frac{8\,P\,D}{\pi\,d^3}$$

in which S = maximum fibre stress in torsion, lb. per square inch; P = load on spring, lb.; D = mean or pitch diameter, in.; d = wire diameter, in. This calculation gives a nominal working-stress range from 26,800 lb. to 50,800 lb. per square inch. However, an additional factor is the effect of curvature and direct shear, which has been well established by A. M. Wahl. With an index $\left(\frac{D}{d}\right)$ of 5·76, the Wahl factor for this spring is 1·26. Multiplying the foregoing stress figures by this factor gives a true stress range from 33,800 lb. to 64,000 lb. per square inch.

In order to illustrate and compare these and subsequent stress cycles, use is made of what may be an unusual method of plotting, shown in Fig. 1, herewith. In this graph, the ordinate scale represents stress values and, instead of an abscissa scale, an oblique reference line is drawn from the origin to some convenient stress value, depending upon the range it is desired to include in the chart. The value of the minimum stress of the cycle is plotted at the intersection of the stress line and the reference line, and the maximum stress of that cycle is plotted vertically above the minimum point, at its appropriate value. Fig. 1 therefore shows line *a* representing the nominal stress cycle, and line *b* giving the cycle with the Wahl correction.

There is another factor which may well influence the stress cycle of the spring, namely, the effect of manufacturing tolerances in spring dimensions. Because of the unavoidable variations encountered in the coiling of helical springs, an overall commercial tolerance of ±10 per cent. must be allowed in the load specification. In this example, this means that the minimum load may be anywhere from 36 lb. to 44 lb., and the maximum from 69 lb. to 84 lb. Therefore, the stress values will vary accordingly, and the least stress value may be (with Wahl correction) 30,100 lb. per square inch, and the greatest value 70,300 lb. per square inch. Usually a spring that is weak on one load will also be weak on the second. Hence, the stress range may be from 30,100 lb. to 57,700 lb. per square inch. Similarly, a spring on the strong side may have a range from 36,800 lb. to 70,300 lb. per square inch, these stresses corresponding to the low and high load values at each specified length. Although not often the case, it is possible that a spring weak on the first load may be strong on the second, or vice versa, due to peculiar variations in length, diameter, and number of coils. The narrowest possible working range is thus from 44 lb. to 69 lb., or 36,800 lb. to 57,700 lb. per square inch, and the widest possible range from 36 lb. to 84 lb., or 30,100 lb. to 70,300 lb. per square inch. This condition is shown by the shaded area of Fig. 2, indicating that any spring out of a large quantity may have a working-stress range somewhere within this area.

A factor which is usually neglected in the design of ordinary machine springs is the inherent susceptibility of helical springs to induced vibrations. Den Hartog has referred to this as "subharmonic" vibration, since impulses, acting on the spring at a frequency which is some fraction of the natural frequency of the active spring helix, can set up resonance in the spring and cause vibrations of serious amplitude within this helix. The larger the ratio of natural frequency to impulse frequency, apparently the smaller is the amplitude of the induced vibration. In most cases, when this ratio is 15 or greater, the vibration will not be serious. In order to study this question, three elements of the mechanism must be known, namely, the speed of operation, the nature of the motion, and the natural frequency of the spring. The speed of operation is the frequency of impulse which may affect the spring. The nature of the motion is important in that, with anything other than a sinusoidal motion, acceleration and deceleration set up inertia forces which play on the elasticity of the helix. Even with sinusoidal motion of the spring and adjacent parts, there may be transmitted to the spring shock from other action of the machine which can have the same effect.

The third consideration, natural frequency of the active helix, lends itself to calculation, although the results are not as accurate as might be desired. Ricardo's formula $n = k\sqrt{\frac{R}{W}}$ (in which n = number of vibrations per minute; k = numerical constant; R = spring rate, lb. per inch; and W = active mass) is widely used in this connection. This equation can be put into a more readily applied form by substituting for R its equivalent from the helical-spring deflection formula, and for W its equal in terms of spring dimensions. These relations are

$$R = \frac{G\,d^4}{8\,N\,D^3}$$

and

$$W = \frac{2{\cdot}67\,\pi\,d^2\,D\,N}{144\,g}$$

where G = modulus of rigidity, N = number of active coils, g = acceleration of gravity, ft. per second per second, and other symbols as before. With these substitutions, the equation simplifies to

$$n = k_1\,\frac{d\sqrt{G}}{N\,D^2}.$$

Values of k_1 have been variously given in the literature and elsewhere, ranging from 216 to 250. A series of stroboscopic tests on springs of about the same size as this example has established an approximate value of 246, and, with this as a basis, the natural frequency of the spring under consideration is 19,800 cycles per minute. The possible inaccuracy of the foregoing formula lies in the proper value of the constant, and also in the determination of the number of active coils. This latter value is difficult to measure exactly and is usually taken from the spring when free, though it decreases slightly when the spring is compressed.

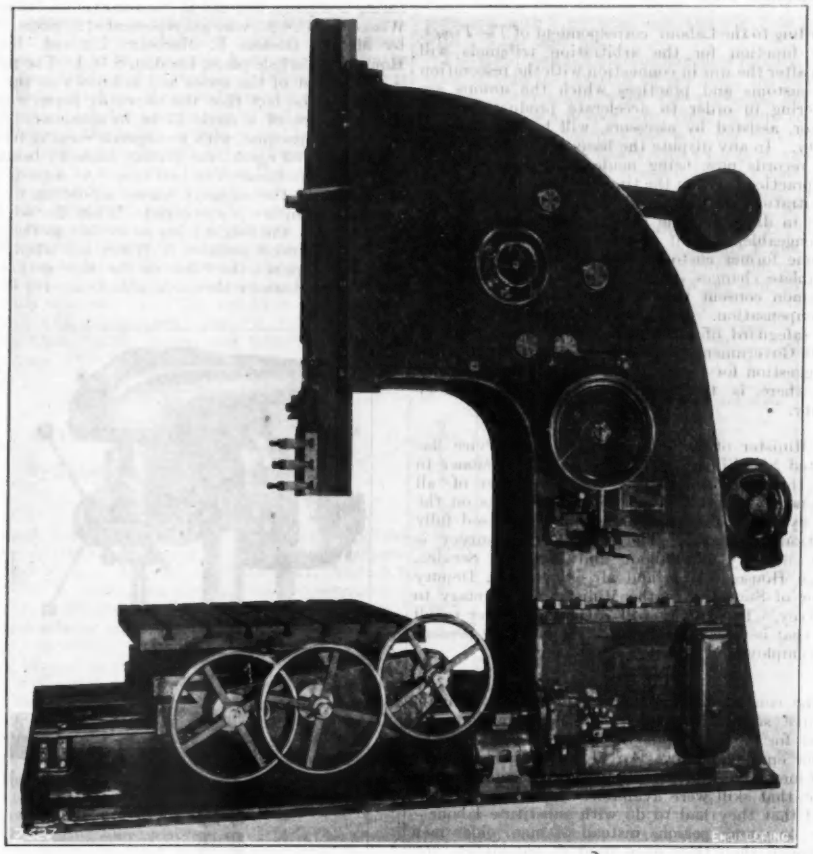
In theory, if the frequency of an impulse acting on the spring is an even fraction, such as $\frac{1}{10}$ of the natural frequency, vibration will occur. Actually, in testing a number of springs, graphical determination of natural frequency shows that the ratio is often something other than a simple fraction; for example, $\frac{1}{9{\cdot}82}$. However, it is well established that, at various steps in a speed range, there will be points roughly corresponding to $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{10}$, etc., of the natural frequency, at which resonance will occur. For purposes of the present discussion, it may be assumed that the spring under consideration is operated at a speed of 1,800 cycles per minute, which is $\frac{1}{11}$ of the natural frequency. In all probability, this is close enough so that some degree of resonance is established. It is readily seen with a stroboscope that a wave travels from one end of the active wire to the other, which causes a momentary displacement of each coil in relation to its adjacent coils. This displacement results in a change in the stress conditions within the three coils. Measurements through the medium of extremely high-speed photography show that it is possible for this displacement (the amplitude of the forced vibration) to become great enough for adjacent coils to touch, or even to strike together noticeably, as the wave passes. For some obscure reason, this does not occur at every resonant speed, but it can and does take place in many instances.

It follows from this fact that the spring may receive the equivalent of solid compression under certain

* Paper presented at the Spring Meeting of the American Society of Mechanical Engineers, at Worcester, Massachusetts, U.S.A., May 1-3, 1940. Abridged.

26-IN. STROKE HEAVY-DUTY SLOTTING MACHINE.

MESSRS. ORMEROD SHAPERS, LIMITED, HEBDEN BRIDGE.



conditions. The fibre stress at solid compression is usually considered only in relation to elastic limit, but, in the light of the present concept, it becomes the end-point in the stress cycle. Calculation gives a value of 79,300 lb. per square inch for the fibre stress of this spring at solid compression. Consequently, the maximum stress of the cycle under vibration may increase to 79,300 lb., instead of 64,000 lb., per square inch, as previously found. Furthermore, if the maximum stress is increased because of the vibration amplitude, which may be called positive, the minimum stress is decreased by an equal negative amplitude. Thus, the stress range is widened markedly under these conditions. This analysis of the vibratory motion and its effect upon the spring is amply supported by high-speed photographic recordings. Therefore, the minimum stress value is decreased by at least 15,300 lb. per square inch and becomes 18,500 lb. per square inch. The new stress cycle which the wire of the spring passes through is shown by line *d* of Fig. 2, although it cannot be said that the spring works through this cycle, since the spring as a whole does not receive this equivalent in deflection. The spring is forced to go through this augmented stress cycle, not at 1,800 cycles per minute, which is the speed of the mechanism, but 11 times as fast, or 19,800 cycles per minute, the natural frequency. This is the explanation for many cases of "short life," or "premature breakage," as measured by time of service.

An important phase of the fatigue problem is always found in the physical properties of the material in question. In the present paper, discussion must be limited to only one of the wide variety of spring materials available, and space is not available to take up all the metallurgical elements which influence the fatigue properties of this one grade of wire. It may be said, however, in summary of a considerable number of investigations, that, in the case of a heat-treated wire, the most important factor seems to be hardness, with minor effects traceable to grain size, analysis, and manufacturing practices. Just as endurance limits have been established for metals under bending stress (rotating-beam tests, etc.), so spring wires have been tested under torsional stress, and diagrams similar to the Goodman type in bending have been established. By means of a number of fatigue tests on actual springs, covering a wide range of stress cycles, with carefully controlled stress conditions, points may be plotted as shown in Fig. 3, opposite. The springs were made of 0·5 C, 0·89 Mn steel, heat treated, and having a Rockwell hardness of 476. These tests can readily show endurance limit by differentiating between failure and non-failure within 5,000,000 cycles to 10,000,000 cycles. A line can be drawn on the graph to mark the differentiation which is then the limiting line for maximum stress in the cycle, and the reference line for plotting becomes the limiting line for minimum stress. It may be noted that plotting in this fashion gives only the useful portion of the complete diagram. Reversed torsional stresses need not be considered for helical-spring purposes, and there is no practical use for information concerning stresses above the elastic limit, so that no good purpose is served by establishing the complete diagram.

Again, in the present considerations, some manufacturing tolerances in the properties of a wire must be allowed. Commercial wires vary about 20,000 lb. per square inch in ultimate tensile strength, and 3 to 4 points in Rockwell hardness. Therefore, in general discussions of fatigue properties, the endurance limit of a certain grade of wire must be considered, not as a definite line, but rather as an area or band, such as is shown in Fig. 4, opposite, which refers to a commercial grade of oil-tempered spring wire, 0·148 in. in diameter. This chart is the result of a number of tests on the same grade of commercial wire, samples being taken from various lots made at various times. Consequently, it well covers the variables encountered in manufacturing operations, and is representative of the spread which may be found in the standard product.

The comparison of fatigue properties of the material with the fatigue requirements of the spring is readily and clearly accomplished by superimposing the chart of Fig. 4 on that of Fig. 2, with the result shown in Fig. 5, opposite. Here it is seen that, because of the variation in endurance limit as discussed and the variation of stress cycle due to spring tolerances, there may be some springs which will fail from fatigue, since the stress cycle in some springs may overlap and exceed the endurance limit of some wire. It will also be seen that the planned working cycle, that is, the mean cycle shown within the shaded area of the chart, does not exceed the endurance limit, the point being, in this instance, that the necessary tolerances throw the stress up into the dangerous area. If the added factor of vibration is present, the effect of tolerances and the planned cycle is submerged, and the forced working cycle is considerably in excess of the endurance limit, indicating certain and rapid fatigue failure.

In summary of the foregoing discussion, it may be stated that the fatigue properties of a helical spring can be established by a comparison of the endurance limit of the material used with the true stress cycle, as determined by design specifications, allowance for curvature and other stress concentrations, and vibration effects. It seems that a large majority of spring failures are accounted for in the true stress values, while there are some, of course, which result from metallurgical factors. Because many springs are designed for limited space, it is not possible to give the allowance for the factors as outlined, which would prevent a large number of spring failures. It is not intended to imply that all springs need to be analysed in the foregoing manner. Fatigue is not a factor in many spring applications, but in those troublesome and annoying cases which do occur quite frequently, this outline gives the method by which the trouble may at least be understood, if not eliminated.

26-IN. STROKE SLOTTING MACHINE.

THE heavy-duty slotting machine shown in the accompanying illustration has been recently developed by Messrs. Ormerod Shapers, Limited, Hebden Bridge, and is capable of handling work up to 7 ft. in diameter by 3 ft. 6 in. high. The stroke may be varied either while the machine is in motion or at rest, up to its maximum of 26 in. It will be clear from the illustration that the column is designed with an exceptional length of ways for the ram and is of great depth from front to back. The heavily-ribbed base, with the table ways of large area, is similarly constructed, with the result that the machine is very rigid under all working conditions. The table is 50 in. square and has longitudinal, transverse and rotary motions. The machine is driven by a 20-h.p. motor mounted on the column at the back, as seen on the right of the illustration. Transmission is by means of multiple Vee-belts, a powerful friction clutch and a nine-speed gearbox housed in the body of the machine. The gears are of heat-treated nickel-chrome steel and are carried on heavy multi-splined shafts. The final drive to the ram has double driving gears and a link, all of steel. The nine ram speeds range from 9 strokes to 35 strokes per minute, the changes being effected by two levers. The length of stroke is varied by a handwheel and a locking device to maintain it constant at the desired length is provided.

The table has a range of power feeds, available in both directions, through a reverse box. The longitudinal traverse is 3 ft. 9 in., and the transverse traverse is 3 ft. 3 in., and it will be clear from the large handwheels on the table that all three motions can be operated by hand feed when desired. The small motor, of 3 h.p., seen near the column foot, provides rapid power traverse to all the motions. This motion is interconnected with the power feed motion in such a manner that the rapid traverse is given in the opposite direction to that of the feed motion. The several gearboxes are pressure-lubricated by a pump, the link motion, etc., being cascade-lubricated. The machine occupies a floor space of 13 ft. by 9 ft. and weighs approximately 11 tons.

THE ALBERT MEDAL.—The Council of the Royal Society of Arts has awarded the Albert Medal for 1940 to Mr. J. A. Milne, C.B.E., a vice-president of the Society, for services to industrial art and in the promotion of the Exhibition of British Art in Industry, as well as for his work in connection with the establishment of the R.D.I. (Royal Designer for Industry) distinction.

IRON AND STEEL CONTROL ORDER.—The Ministry of Supply has made a new Order entitled the Control of Iron and Steel (No. 11) Order. This Order, which came into force on July 8, prohibits, with certain exceptions, the use of iron and steel for buildings, except under licence. The intention of the new Order is to stop the consumption of iron and steel already in the hands of contractors or consumers, and the sale of iron and steel by stockholding merchants, for non-essential buildings. No licence will, however, be required for the use of steel for building where the purchase of that steel has been authorised by a Department for that purpose under the Steel Distribution Scheme, or has been licensed by the Ministry of Supply (Iron and Steel Control) on or since April 1, 1940. In order to cover urgent requirements for repairs and maintenance, the use, or the purchase from a stockholder, of less than one ton in one month for any particular building is exempt from the licensing scheme. Any application for a licence to use iron or steel under this Order should be made to the Department to which application would be made for authority to purchase steel under the Steel Distribution Scheme.

LABOUR NOTES.

ADDRESSING the annual conference of the National Union of Railwaymen—which was held at Morecambe last week—Mr. J. H. Potts, the president, dealing with the subject of wages, said that one of the main features of the negotiations, apart from the success achieved—success which meant total increases of 11,000,000*l.* a year—had been the temporary suspension of the sliding-scale arrangements. That had been received with approbation on the one hand, and condemnation on the other. In his opinion, even in peace time, the method of ascertaining the cost of living figure was out of date.

The conference unanimously adopted a resolution calling upon the Government to prepare plans for the complete co-ordination of all forms of transport under public ownership and control. Mr. Marchbank, the general secretary of the organisation, explained that the resolution visualised the taking over under public control of all transport by road, rail, sea or air. The financial structure of the railways was such that in the hands of private enterprise it could not be maintained without Government aid. That in itself was an indication that the changes proposed in the resolution, and proved to be necessary in time of war, would be essential at the end of the war. The London Passenger Transport Board went a long way towards the unification and public ownership which had been advocated for many years. A word of warning must be given, however. When the change did come, the taking over of transport must be on a fair basis and not on a basis that would make it a liability on the taxpayers.

The annual conference of the General Federation of Trade Unions was held at Blackpool last week. Mr. A. Naesmith, of the Amalgamated Weavers' Association, who presided, said, in the course of his introductory address, that even in these times of tension it was necessary to remember the necessity of a new social order. A nation must continuously strive to improve the economic conditions of its people to justify its existence. The retention of democratic forms of government and free institutions was a mere sham unless by means of them economic freedom for the people became a reality, and security and improved social standards of life were assured. "We ought to be able to say," Mr. Naesmith continued, "that the worst evils that followed the last war will be avoided this time. Peace will come, and we must be prepared. Planning on a scale never before attempted should be undertaken by the nation. To that end, the Trade Union Movement with its great experience and knowledge, should be fully utilised—not grudgingly, but with the fullest recognition—now that it is an integral part of the democratic machinery of the State."

The council of the General Federation of Trade Unions has decided to lend to the Government 10,000*l.* free of interest for the period of the war. It has also decided to invest 10,000*l.* in the 2½ per cent. National War Bonds and to give 600*l.* to the Red Cross. The Warehousemen and Clerks' Association has lent the Treasury 2,500*l.* for the duration of the war, free of interest.

After explaining the provisions of the Unemployment Insurance Bill—which was given a second reading in the House of Commons last week—Mr. Bevin, the Minister of Labour and National Service, announced two regulations which he proposed to make for the war period only and which did not come within its provisions. While he declared himself averse from anything of a penal character in connection with the social services, he intended, he said, to limit the amount of unemployment benefit payable to any person disobeying a Defence of the Realm Regulation in relation to employment. The effect of that would be that the person convicted by a court of summary jurisdiction could be made to suffer loss of benefit up to a maximum of six weeks. The other regulation was intended to cover the case of persons refusing to accept work of national importance at the trade union rate of wages because of the expectation of obtaining work at higher wages.

It is understood that legislation is soon to be introduced providing for compulsory arbitration in wages disputes for the period of the war. Under it, there will be no interference with existing negotiating machinery in any industry or trade, and unions will be free as at present to make claims and pursue negotiations in the normal way. But if no settlement is reached through negotiations, the difference will have to go to arbitration. Strikes and lock-outs during the war will be prohibited. Where a trade or industry has no provision for arbitration its disputes will go to a new National Arbitration Tribunal—a small body consisting of nominees of the Minister of Labour and National Service, the employers, and the Trades Union Congress. The principles of the proposals, it is stated, have the approval of the Consultative Committee of representatives of the Trades Union Congress and the British Employers' Confederation, but their application has called for, and is probably still calling for, a good deal of detailed work.

According to the Labour correspondent of *The Times*, another function for the arbitration tribunals will develop after the war in connection with the restoration of the customs and practices which the unions are surrendering in order to accelerate production. An arbitrator, assisted by assessors, will be the deciding authority. In any dispute the basis of the inquiry will be the records now being made of departures from former practice. When the time for restoration comes, the arbitration tribunals will be ready to adjudicate in cases in dispute. The right to restoration will be unchallengeable, but it may, nevertheless, happen that some former customs may be rendered obsolete by complete changes in workshop practice, and that by common consent they will lapse, though perhaps with compensation. Anyhow, the writer says, instead of the safeguard of an addendum to the fair wages clause in Government contracts, which was Mr. Bevin's first suggestion for ensuring the restoration of former rights, there is to be arbitration with statutory authority.

The Minister of Labour and National Service has appointed Sir William Beveridge as Commissioner to survey the available resources of man-power of all kinds and to report thereon with suggestions on the means by which these resources can be utilised fully for national purposes. The office of the survey is at the Ministry of Labour and National Service, Montagu House, S.W.1, and Mr. A. Reeder, Deputy Director of Statistics in the Ministry, is secretary to the survey. The survey will cover man-power in all forms, that is to say, men, women, and young persons now in employment or out of employment.

In the course of a broadcast address, Sir William Beveridge said that while there was an immense demand for certain kinds of labour, labour offering itself for employment was largely of a different kind. Skilled men were wanted. Innumerable women hands without that skill were available. In war, employers learned that they had to do with substitute labour—women or young persons instead of men, older men and women than they were used to employing, and people who had to be taught their job. Employers must do these things rather than hold up production, and they must not use for simple jobs people who could do something harder. His business was to find out what kind of substitutes for skilled and experienced labour could be provided and how the substitutes could best be fitted to the national need.

In their seventh report, the Select Committee on National Expenditure suggest that "in the interest both of maintaining the efficiency of labour and of keeping down costs, overtime in ship-repair yards should be carefully watched, and Sunday work, in particular, should be restricted except where it is definitely necessary." While noting the ready response to the Government's appeal for work on every available day, and the postponement of all holidays until the situation improves, the report states that convincing evidence was given to the sub-committee that in the ship-repairing industry regular Sunday labour on top of a full week's work not only greatly adds to the cost, but in the long run, if practised generally, actually defeats its purpose by imposing undue strain on the men.

Some old-established yards, the report adds, have found that over a period of time Sunday work, far from increasing output, reduces efficiency and adds seriously to the cost. But because double wages, and even more, may be earned on Sunday, some of the men are not unfavourable to the practice. The report notes that as employers are paid on a cost plus profit basis, it is not in their financial interest to avoid Sunday labour, and that in some cases at certain ports men have earned exceptionally high wages by working overtime almost continuously.

THE LATE MR. G. E. WOLSTENHOLME.—We have learned with regret of the death of Mr. George Ethelbert Wolstenholme, M.I.Mech.E., on July 3, following an operation. Mr. Wolstenholme, who was formerly chairman of the Yorkshire Branch of the Institution of Mechanical Engineers, was a local director of Messrs. Thos. Firth and John Brown, Limited, Sheffield, and was also a director of the Firth-Brearley Stainless Steel Syndicate, Limited. He was 65 years of age.

PILLAR-TYPE SENSITIVE DRILLING MACHINES.

THE unusual type of sensitive drilling machine shown in the accompanying illustration is representative of a series recently introduced by Messrs. Tauco Manufacturing Company, 600-634 E. Vienna-avenue, Milwaukee, Wisconsin, U.S.A., who are represented in Great Britain by Messrs. Gaston E. Marbaix, Limited, Humglas House, 22, Carlisle-place, London, S.W.1. The machine is the largest of the series and is known as the 17-in. drill from the fact that the overhang permits drilling in the centre of a circle 17 in. in diameter. It is a high-speed machine, with five speeds ranging from 700 r.p.m. to 4,750 r.p.m., the drilling capacity being holes up to ¾ in. in diameter in cast iron. As regards height of the work, the capacity varies according to which supporting surface is employed. When the adjustable table is used, the height from its surface to the spindle nose in its lowest position is 34 in., but when greater height is required the table on the base may be employed, the distance then available being 44½ in. The

spindle has a traverse of 5 in. The adjustable table is normally arranged to swivel on a horizontal axis through 180 deg., and, as will be seen, is traversed by rack and pinion gear. Its surface is 11 in. by 12 in., and that of the base table is 10 in. by 13¾ in.

The drive is through a Vee-belt from a ¾-h.p. motor bolted to a bracket on the head. The driving and driven pulleys have five grooves; the driven pulley is keyed to the spindle. The belt pull, however, is taken by two sealed ball bearings, one immediately above and the other well within the hollow pulley. Below this latter bearing the spindle is formed with 16 splines engaging with an exceptionally long sleeve attached to the spindle nose, which is carried in two ball bearings at the bottom of the quill. Vertical traverse of the quill is effected by rack and pinion gear actuated by the capstan wheel seen to the right. The quill is operated against, and returned by, a spirally-coiled spring, the tension of which is adjusted by worm winding gear to eliminate the possibility of uncoiling. The dial seen on the end of the feed-pinion spindle is a depth gauge, a vertical traverse depth gauge attached to the quill being also fitted. An alternative feed arrangement is by pedal. The machine illustrated is 66 in. in overall height and is of the floor type. It is also made as a bench-type machine, in which case the head has a rack and pinion traverse and the height is 42½ in.

Two other sizes of machine are included in the series, viz., a 14-in. and an 11-in. size, this dimension referring to the diameter of the largest circle that can be drilled in the centre. The 14-in. machine has a drilling capacity of ½ in. in diameter in cast iron, a table traverse of 43 in. and a spindle traverse of 4 in. It has four speeds ranging from 590 r.p.m. to 5,000

r.p.m., and a motor of ½-h.p. The 11-in. machine will drill holes up to ⅝ in. in diameter in cast iron, has a maximum depth from chuck to table of 14 in., a spindle traverse of 4 in., four speeds, and a motor of the same rating as the 14-in. machine. It may be noted that the 17-in. and 14-in. machines can be used, with a special attachment, as morticing machines for woodwork, and can also be fitted with tapping attachments. The 14-in. and 11-in. machines have an arrangement of quill and driven pulley mounting different from that of the 17-in. machine, the spindle in the region of the pulley being carried in a single ring of ball bearings. The actual drive of the pulley is transmitted to the spindle through a floating sleeve with external spur gear teeth. These mesh with an internal gear in the pulley, so that the sleeve can float relatively to the pulley. The sleeve drives the spindle through splines and the arrangement relieves the spindle of all belt pull. It is stated that the spindle retains its alignment under all conditions. The belts are fully guarded in all three sizes of machine and the speed variations by belt-changing are readily effected. The 17-in. and 14-in. machines are also made with a slow-speed range, viz., from 385 r.p.m. to 2,240 r.p.m. in the former and from 390 r.p.m. to 2,050 r.p.m. in the latter.

A COAL-CLEANING POLICY.*

By ARTHUR A. HIRST, D.Sc., F.Inst.P.

(*Concluded from page* 20.)

So much has been written in favour of cleaner and yet cleaner coal, culminating in the demand for pure coal, that it may be well to recall that Grumell,† who originally advocated the commercial production of pure coal, rightly pointed out that it was not economically desirable to use low-ash coal for any and every purpose. Recently, Crawford‡ has shown that the cleaning of coal, even at a specific gravity as high as 1·6, may result in a total loss of 4·5 per cent. of the heat available in the raw material. Any scheme for the production of pure coal must provide for the utilisation of middlings. Frequently, it will be found that the problem of producing pure coal is easier of solution than the problem of adequately disposing of the middlings. There is a limit to the amount of low-grade fuel that a colliery can burn, and, in any case, most pits have existing sources of low-grade fuel. As stated earlier, in a competitive market, coal with an ash content substantially greater than 7 per cent. is not easy to sell and, when sold, usually realises a low price. If, therefore, the middlings have to be sold at a low price, the pure coal will have to be sold at a high price.

The saleability of middlings depends principally on their ash content. In the production of pure coal with a given ash content, the ash content of the middlings is rigidly related to the ash content of the primary cleans and the yield of clean coal. Table III, on this page, shows, for yields of pure coal varying from 30 per cent. to 90 per cent., and for primary cleans varying from 4 per cent. to 6 per cent. ash, the ash content in the middlings obtained when making a pure coal with either 2 per cent. or 1·5 per cent. ash. Figs. 2 and 3, on this page, show graphically the relationships expressed in Table III. Fig. 2 relates to pure coal with 2 per cent. ash, and Fig. 3 to pure coal with 1·5 per cent. ash.

TABLE III.—*Relationship Between Ash in Middlings, Ash in Primary Cleans, and Yield of "Pure" Coal.*

Pure Coal.		Middlings.					
Ash. Per Cent.	Yield. Per Cent.	Ash. Per Cent.					Yield. Per Cent.
2·0	30	4·9	5·6	6·3	7·0	7·7	70
	40	5·3	6·2	7·0	7·8	8·7	60
	50	6·0	7·0	8·0	9·0	10·0	50
	60	7·0	8·3	9·5	10·8	12·0	40
	70	8·7	10·3	12·0	13·7	15·3	30
	80	12·0	14·5	17·0	19·5	22·0	20
	85	15·3	18·7	22·0	25·3	28·7	15
	90	22·0	27·0	32·0	37·0	42·0	10
1·5	30	5·1	5·8	6·5	7·2	7·9	70
	40	5·7	6·5	7·3	8·2	9·0	60
	50	6·5	7·5	8·5	9·5	10·5	50
	60	7·8	9·0	10·3	11·5	12·8	40
	70	9·8	11·5	13·2	14·8	16·5	30
	80	14·0	16·5	19·0	21·5	24·0	20
	85	18·2	21·5	24·8	28·2	31·5	15
	90	26·5	31·5	36·5	41·5	46·5	10
		4·0	4·5	5·0	5·5	6·0	
		Ash in Primary Cleans, Per Cent.					

Fig. 2. Yield of Middlings...per Cent.

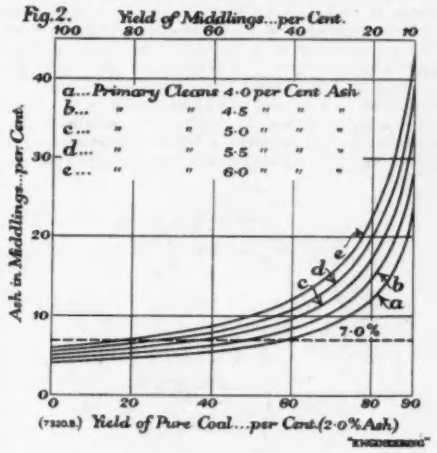
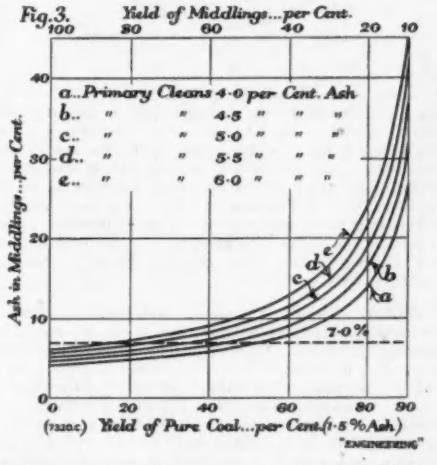

100 80 60 40 20 10
a...Primary Cleans 4·0 per Cent Ash
b... " " 4·5 " " "
c... " " 5·0 " " "
d... " " 5·5 " " "
e... " " 6·0 " " "
Ash in Middlings...per Cent.
7·0%
0 20 40 60 80 90
(7320A) Yield of Pure Coal...per Cent.(2·0% Ash)
"ENGINEERING"

Fig. 3. Yield of Middlings...per Cent.


100 80 60 40 20 10
a...Primary Cleans 4·0 per Cent. Ash
b... " " 4·5 " " "
c... " " 5·0 " " "
d... " " 5·5 " " "
e... " " 6·0 " " "
Ash in Middlings...per Cent.
7·0%
0 20 40 60 80 90
(7320C) Yield of Pure Coal...per Cent.(1·5% Ash)
"ENGINEERING"

The middlings ash content increases rapidly when the yield of pure coal exceeds 60 per cent., the effect being particularly marked when the pure-coal ash is 1·5 per cent. For a 50-per cent. yield of pure coal, 2 per cent. ash, the middlings ash is 7 per cent. or under, but only for primary cleans with 4 per cent. and 4·5 per cent. ash; for primary cleans with 5 per cent., 5·5 per cent. and 6 per cent. ash, the corresponding middlings ash contents are respectively 8 per cent., 9 per cent. and 10 per cent. If the pure coal has 1·5 per cent. ash and the yield is 50 per cent., only primary cleans with 4 per cent. ash give a middlings ash under 7 per cent., though the ash is only 7·5 per cent. in the case of primary cleans with 4·5 per cent. ash. The middlings ash contents are 8·5 per cent., 9·5 per cent. and 10·5 per cent. for primary cleans with ash contents of 5 per cent., 5·5 per cent. and 6 per cent., respectively.

An increase in the ash content of the primary cleans is accompanied by a much larger increase in the ash content of the middlings, the increase in the middlings ash being greater for higher yield of pure coal. Clearly, therefore, in the preparation of the primary cleans, an accurate separation is specially desirable. In my opinion, the ash content of the primary cleans should not exceed 5 per cent., a rather lower ash being preferable. The relationships expressed in Table III and Figs. 2 and 3 are arithmetical relationships, and the corresponding separations are not necessarily possible, either theoretically or practically. If, however, it is possible to obtain a given yield of pure coal, any lower yield may be obtained simply by the method of mixtures.

Suppose that the primary cleans, obtained by separating at approximately 1·5 sp. gr., have 4·5 per cent. ash. If re-separated at 1·35 sp. gr., the yield of pure coal might be 80 per cent. and its ash content 2 per cent., the corresponding middlings ash being 14·5 per cent. By mixing part of the pure coal with the middlings, it is possible to obtain 50 per cent. of pure coal with 2 per cent. ash and 50 per cent. of middlings with 7 per cent. ash. Similarly, if the ash content of the primary cleans is 4 per cent., it may be possible to obtain, either 85 per cent. pure coal with 2 per cent. ash and 15 per cent. middlings with 15·3 per cent. ash, or, alternatively, 50 per cent. pure coal with 2 per cent. ash and 50 per cent. middlings with 6 per cent. ash. The alternative separations are compared in Table IV.

TABLE IV.—*Alternative Separations.*

——	Tons.	Ash. Per Cent.	Tons.	Ash. Per Cent.
1. Primary cleans ..	100	4·5	100	4·0
2. Pure coal	80	2·0	85	2·0
Middles	20	14·5	15	15·3
3. Pure coal	50	2·0	50	2·0
Middles	50	7·0	50	6·0

Process 3, in which the yield of pure coal is deliberately sacrificed with a view to obtaining a marketable middlings, appears to offer attractive possibilities, particularly when used in the production of low-ash coal for preparing smokeless fuel. In this case, coal with 6 per cent. ash would be very little inferior, as a boiler fuel, to coal with 4 per cent. ash, and the enhanced value of the pure-coal fraction will be mostly profit. Process 3, which may be termed the method of partial separation, obviously does not necessitate a particularly accurate separation, since it aims at a 50 per cent. yield of pure coal when a considerably higher yield may be theoretically possible. Using a high grade coal—and for the reasons described earlier this provision is desirable in any case—a jig washer will easily effect the desired separation, even when treating fines; although the separation obtained, being only partial, may not suffice for some special purposes, as, for instance, when it is desired to separate bright and dull coal.

It may be contended that, by separating at a specific gravity lower than that required to give a pure coal with 2 per cent. ash, it would be possible to obtain a middlings with an ash content under 7 per cent., together with a "pure" coal of exceptionally low ash. The contention is justified, but difficulties may be involved. Fig. 1, page 19, *ante*, indicates that the ash content of the 1·35 to 1·60 sp. gr. fraction in the primary cleans will normally be well over 10 per cent., so that, to obtain a middlings with under 7 per cent. ash, it will be necessary to separate at a specific gravity less than 1·35. The problems encountered in separating at specific gravities lower than 1·35 are best illustrated by an actual example.

Table V, below, gives a detailed fractional float-and-sink analysis of two sizes of the same washed coal and demonstrates the force of two observations which are typical of the problem, namely, that the reduction in ash content accompanying a lower specific gravity of separation is not marked, and in extreme cases, may bring about an increase in ash; and that separation becomes exceedingly difficult on account of the large proportion of material with a specific gravity very close to the specific gravity of separation.

TABLE V.—*Fractional Float-and-Sink Analysis of Two Sizes of the Same Washed Coal.*

1½ in. to ⅜ in.			⅜ in. to ⅛ in.		
Specific Gravity.	Weight. Per Cent.	Ash. Per Cent.	Specific Gravity.	Weight. Per Cent.	Ash. Per Cent.
1·28 float	1·4	1·23	1·24 float	0·9	1·43
1·28–1·29	8·5	1·20	1·24–1·26	4·5	1·01
1·29–1·30	31·3	1·29	1·26–1·28	9·2	1·05
1·30–1·31	19·5	1·47	1·28–1·29	35·2	1·09
1·31–1·32	15·2	1·51	1·29–1·30	19·3	1·23
1·32–1·34	16·5	1·78	1·30–1·32	13·5	1·78
1·34 sink	7·6	—	1·32–1·34	4·3	2·74
			1·34 sink	13·1	—

Consider the difficulty of accurately separating the 1½-in. to ⅜-in. size at a specific gravity of 1·30. When separating at 1·30 sp. gr., 41·2 per cent. floats and 58·8 per cent. sinks. If, however, the specific gravity of separation should fluctuate as little as ±0·01, the yield of floats would vary from 9·9 per cent. to 60·7 per cent. and the yield of sinks from 90·1 per cent. to 39·3 per cent. To say the least, such variations in yield would render working a little difficult. The ash content of the pure coal would be substantially unaffected by the variations in yield, but the middlings ash content would fluctuate over a wide range. By way of comparison, when a jig is used to prepare a pure coal and saleable middlings, the pure-coal ash is not quite so low as would be obtained by a specific-gravity separation; but, on the other hand, the yield of pure coal and the ash content of the middlings remain substantially constant. As the purest coal is usually found in the finest sizes, the ability of a jig to treat fines is a point in its favour.

* Paper presented at a meeting of the Institute of Fuel, in London, on Thursday, May 30, 1940. Abridged.

† "Pure Coal." by Dr. E. S. Grumell, Trans. Inst. Min. Eng., vol. 87, page 260.

‡ "The Physical and Chemical Impurities in Coal," by Crawford: 3rd Annual Conference, Combustion Appliance Makers' Association.

THE MERCURY INDUSTRY OF THE UNITED STATES.

STATISTICS issued recently by the Bureau of Mines at Washington, regarding the mercury industry of the United States during 1939, indicate that difficulties in obtaining mercury from Europe led to increases in the price of the metal which have had the effect of stimulating home production. The increase in the production at mines in the United States, however, only began towards the end of the year and while the output for 1939, namely, 18,633 bottles, each of 76 lb., was the highest recorded since 1931, it was only 10 per cent. above the average for the five-year period 1934-38. Nevertheless, as there were 107 mines in production at the end of the year 1939, as compared with 91 at the end of 1938, it may reasonably be assumed that the renewal of activity had not yet had time to make itself felt. Of the total of 18,633 bottles, just quoted, nearly 60 per cent. were produced at 59 mines in the State of California, while Oregon, which was responsible for an output of 4,592 bottles, or 25 per cent., was second in order of production. Twenty-five mines in the State of Nevada produced 828 bottles, or 4 per cent. of the 1939 output, and the remaining 2,086 bottles, or 11 per cent. of the total, came from nine mines scattered over the States of Arizona, Arkansas, Idaho and Texas.

Imports of mercury for consumption in the United States rose from 2,362 bottles in 1938 to 3,499 bottles in 1939, and it is interesting to note that 2,887 bottles entered the country during the last two months of 1939. Last year, Spain supplied 2,601 bottles, Mexico 562 bottles, and Italy 336 bottles. Exports of mercury totalled 1,208 bottles in 1939, compared with 713 bottles in 1938, and of the 1939 total 304 bottles were consigned to Canada, 206 to the United Kingdom, and 177 each to Japan and to the South American Continent. In conclusion, some information concerning the rise in price of quicksilver in the United States, last year, may be of interest. In January, 1939, the average price for the month was 77·44 dols. per bottle, and owing to difficulties brought about by the Spanish civil war prices rose somewhat in the succeeding months. At the conclusion of hostilities in Spain, however, the prices declined, but rose again sharply to as much as 140 dols. per bottle, in September, as a result of the outbreak of war in Europe. Since September, the upward tendency has continued in the United States.

CATALOGUES.

Dust Collection.—Messrs. Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C.4, have sent us a pamphlet (No. 1160) illustrating diagrammatically some typical arrangements of the Ter Linden cyclone dust collector.

Rectification Systems.—A pamphlet entitled "Constant Potential Rectification," sent to us by Messrs. Westinghouse Brake and Signal Company, Limited, Pew Hill House, Chippenham, Wiltshire, deals with their "Noregg" and "Westat" systems of rectification.

Fuse Carriers.—Messrs. British Insulated Cables, Limited, Prescot, Lancashire, have published a leaflet describing their shrouded fuse carriers. They are available in sizes suitable for 150, 300 and 500 amperes, and are interchangeable with the key-operated carriers in existing pillars and units of their dwarf and short types.

Industrial-Lamp Reflectors.—Messrs. The British Thomson-Houston Company, Limited, Crown House, Aldwych, London, W.C.2, have sent us a list dealing with Mazdalux industrial reflectors for use with their 400-watt Mercra lamp, which has been developed to simplify installation by incorporating the choke in the reflector.

Portable Electric Tools.—We have received from Messrs. Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, a catalogue of electric sanders, drills, grinders and other tools, of American design, for which their associated firm, Messrs. Stanelco Products, has entered into manufacturing and selling agreements.

Fixing Devices.—From Messrs. The Rawlplug Company, Limited, Rawlplug House, Cromwell-road, London, S.W.7, we have received a booklet which describes the various devices made by this firm and includes particulars of tools designed to simplify their fixing. Details are given of tests made at the National Physical Laboratory with Rawlplug expansion bolts.

Instrument Wire.—Messrs. The Scott Insulated Wire Company, Limited, Queensland Works, Westmoreland-road, London, N.W.9, as a result of investigations, have produced "Manganamron," which is a drawn, insulated, copper-nickel-manganese wire, suitable for precision instruments, shunts, etc. Cards received from this firm list the physical properties of this and other products.

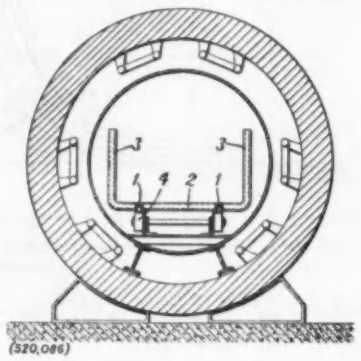
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

FURNACE APPARATUS.

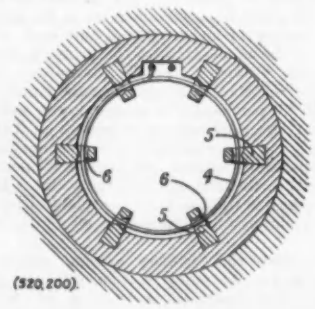
520,086. Skip. G.W.B. Electric Furnaces, Limited, of London, and J. MacDonald, of London. (2 *Figs.*) October 11, 1938.—Skips have a tendency to distort due to uneven heating or sudden quenching, which, in turn, is due to variation in thickness of the metal, and the object of the invention is to obviate this difficulty. The skip consists of two longitudinals 1 of hollow rectangular section and of even wall thickness throughout. Transverse members 2, also of hollow rectangular section, are welded to the longitudinals. The transverse members are bent up at their ends to form side posts 3. The skip



(520,086)

is shown in an electric furnace having a roller-way 4. The longitudinals 1 rest on the rollers so that the skip can be moved easily into or out of the furnace. The longitudinals and the transverse members are of the same rectangular section and are arranged so that in the longitudinals, the longer side is vertical and in the transverse members, it is horizontal. For use in long furnaces, several skips are connected end to end by inserting pieces of smaller section into the open ends of the longitudinals and passing locking pins through them. (*Accepted April* 15, 1940.)

520,200. Electric Furnace. Wild-Barfield Electric Furnaces, Limited, of London, and G. H. S. Grene, of London. (2 *Figs.*) October 14, 1938.—The invention is a form of furnace which is cheap to manufacture and can be quickly assembled. The wall of the electric heating furnace of a saltpot is cylindrical with its axis vertical. Round the inner surface are a number of vertical grooves of dovetailed cross-section. The heater 4 is a continuous coil of resistance rod on which are threaded a number of refractory blocks 5. Each block is of wedge-shaped cross-section, and is a sliding fit in the dovetail grooves. The block is drilled at its thinner end with a hole 6, which flares at each end, and through which the heater is passed. The blocks are threaded on to the

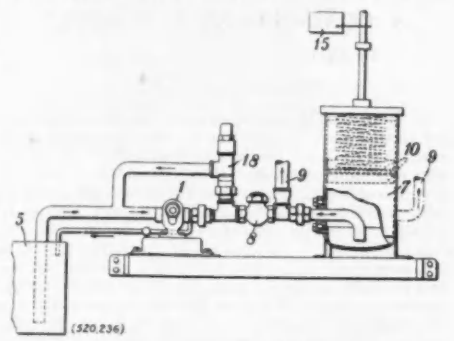


(520,200)

heater coil and spaced round each turn. The assembly is then inserted into the furnace, the blocks sliding into the vertical grooves and resting on one another so as to space the turns of the coil. Distance pieces at the end of the furnace raise some of the sets of blocks according to the pitch of the coil. Each turn of the heater is supported at a number of points and is spaced from the wall of the furnace. Hence the latter need not be of a highly refractory nature and a considerable saving can be made in the cost of the furnace; more rapid heating and cooling is possible owing to the relatively small absorption of heat. Where it is necessary to provide for greater heating at some parts than at others, the pitch of the coil is varied by grading the sizes of the supporting blocks 5 to increase the number of turns per foot length of the furnace. (*Accepted April* 17, 1940.)

HYDRAULIC APPARATUS.

520,236. Oil-Dispensing Apparatus. Tecalemit, Limited, of Brentford, and C. C. S. Le Clair, of Brentford. (5 *Figs.*) October 13, 1938.—The apparatus is of the kind employing an electrically-driven pump which is controlled by variations of oil pressure in a pilot pressure vessel. The object of the invention is to enable a number of pumping units, each having its own pilot pressure vessel, to be operated by a single electric motor. The pump 1 of each unit is geared to the electric motor. The suction side of the pump is connected to an oil-storage tank 5, while the delivery side is connected to a pilot pressure vessel 7. Between the pump and the pilot pressure vessel is a non-return valve 8 and a delivery nozzle 9 in that order. The pilot vessel 7 consists of a container in which is a spring-loaded piston 10. Oil from the pump 1 is forced into the vessel below the piston



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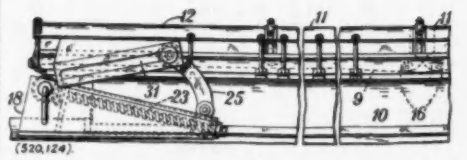
which, as it rises, operates a switch 15 controlling the contacts of the electric-motor starter. In the operation of each unit, assuming the delivery nozzle 9 is closed, oil from the storage tank 5 is forced by the pump through the non-return valve 8 into the pilot pressure vessel 7 below the piston, the pressure rising until the piston opens the switch 15 controlling the starting contactor of the motor. Immediately the delivery nozzle is opened, oil from the vessel 7 is forced through the nozzle by the spring. The piston then descends and restarts the motor. The driving shafts of all the pumps of a battery are coaxial with a shaft driven by the motor, the units being equally spaced on each side of the motor. All the switches controlling the motor starter are connected in parallel. Thus, as long as the pressure in one of the vessels 7 remains below a predetermined value, the motor continues to drive the pumps. Each pump has a by-pass valve 18 leading back to the inlet to protect the pump when the pressure in its associated vessel 7 has reached the given value. (*Accepted April* 18, 1940.)

SHIPS AND NAUTICAL APPLIANCES.

520,124. Ship's Hatch. The Gas Light and Coke Company, of London, and S. Hay, of London. (7 *Figs.*) September 13, 1938.—The hatch has the usual rectangular frame 10 on the ship's deck, across which extends two folding hatch-covers, each being in two parts 11 and 12. The part 12 is hinged to the frame and the two adjacent edges are hinged together. Each free corner of the part 11 carries a bracket on which is mounted a roller 16. The roller engages a track on the frame which terminates in a ramp 9 at the closing end. On the deck along each



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side of the hatchway is an open-topped sheet-steel box 18, in which is mounted a lead-screw 23. The lead-screw is engaged by a nut carrying an arm 25, the upper end of which is forked to carry a roller. The roller engages a track 31 on the cover part 12, and both the lead-screw and the track are inclined to the horizontal. The lead-screw 23 is driven by bevel gears from a cross-shaft, which also drives the lead-screw on the other side of the frame. The pitch of the lead-screw is small enough to lock the cover in any position. There is a watertight joint between the edges of the cover parts, consisting of a rubber strip clamped between overlapping flanges by hand-screws. (*Accepted April* 16, 1940.)